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Mariners Weather Log

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Cover: Angry waves pound Minot Lighthouse on February 8, 1978. An infamous northeaster wrought havoc along the New England coastline. For a description of this storm see North Atlantic February "Monster of the Month" on page 212. UPI Photo.

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The Secretary of Commerce has determined that the publication of this periodical is necessary in the transaction of the public business required by law of this Department. Use of funds for printing this periodical approved by the Director of the Office of Management and Budget through June 30, 1980.

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Mariners Weather Log

EXTRATROPICAL STORM-RELATED BEACH EROSION

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National Weather Service, NOAA
Silver Spring, Md.

INTRODUCTION

Our oceans, rivers, and lakes have been changing our shorelines for thousands of years. These changes are part of a natural process in which a dynamical balance between the shoreline and surrounding water is maintained. By advancing and retreating, the shoreline responds to winds, tides, waves, breakers, swell, and long-term changes in sea level. Rates of beach accretion (advancing beach) and beach erosion (retreating beach) may be measured over several time scales. Long-term rates are measured in years, seasonal rates in months, while rates related to storms are measured in days or hours. This article addresses the beach erosion measured over the shortest of these time scales, namely extratropical storm-related beach erosion.

STORM-RELATED EROSION

Storms with large erosion potential can occur each year. The photographs in figure 1 show beach erosion and the damage resulting from beach erosion at locations along the East Coast. The damage shown in these photographs was caused by five extratropical storms. Qualitative beach erosion estimates associated with these storms are tabulated in table 1.

The paths of the five storms (fig. 2) are of two general types. Storms with Path I (February 19 and 20, 1972, and March 17 and 18, 1976) followed a northeasterly course along the New England coast. The two storms associated with this path caused severe and major erosion along the New England coast (fig. 1, photos 2 and 3). Path II storms (March 6 to 9, 1962, February 9 to 11, 1973, and December 18 and 19,

Table 1. Qualitative estimates of beach erosion associated with the five extratropical storm tracks shown in Figure 2 (condensed from Richardson, 1977).

STATES	STORMS				
	PATH I		PATH II		
	Feb. 19-20, 1972	Mar. 17-18, 1976	Mar. 6-9, 1962	Feb. 9-11, 1973	Dec. 18-19, 1977
Maine	Severe	Major	Minor	None	*None
New Hampshire	Minor	None	Minor	None	*None
Massachusetts	Severe	Major	Minor	None	*None
Connecticut	Minor	None	Moderate	None	*None
Rhode Island	Severe	None	Major	None	*None
New York	Minor	None	Severe	None	*Minor
New Jersey	None	None	Severe	None	*Minor
Delaware	None	None	Severe	None	*Major
Maryland	None	None	Severe	Major	*Severe
Virginia	None	None	Severe	Severe	*Minor
North Carolina	None	None	Severe	Major	*None
South Carolina	None	None	Minor	None	*None
Georgia	None	None	None	None	*None
Florida	None	None	Major	None	*None

* Preliminary estimates

Photo 3.--Kennebuck Beach, Maine, after February 1972 storm. The Boston Globe.

Photo 2.--Plum Island, Mass., after March 1976 storm. The Boston Globe.

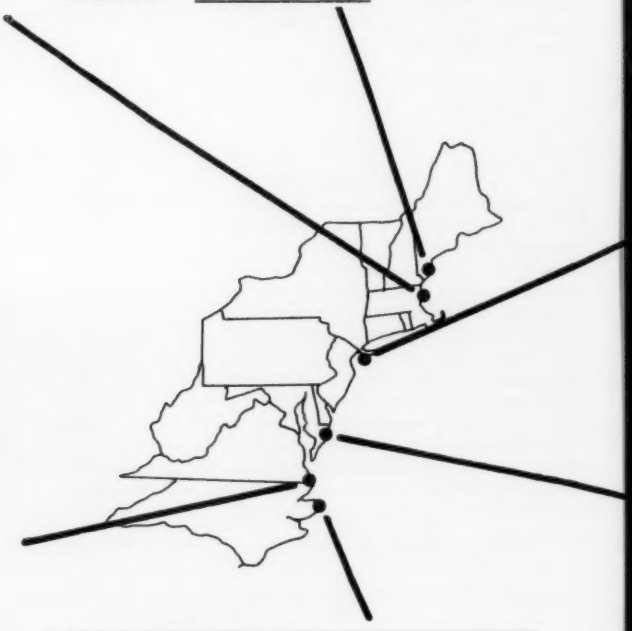

Photo 1.--Virginia Beach, Va., after March 1962 storm (N.A. Pore).

Photo 6.--Nags Head, N.C., after February 1973 storm (U.S. Army Coastal Engineering Research Center).

Figure 1.--Photographs of beach erosion and damage due to beach erosion at locations along the East Coast.

Photo 4.--Fire Island, N.Y., after March 1962 storm UPI Photo.

Photo 5.--Ocean City, Md., after December 1977 storm (N.A. Pore).

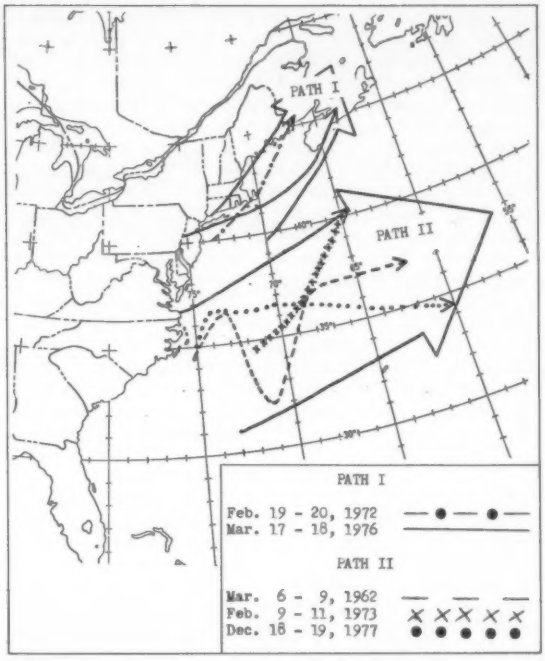

Figure 2.--Paths of extratropical storms which were associated with beach erosion events.

1977), which moved off the Carolina coasts in an east-northeasterly direction, caused a great deal of erosion from Rhode Island south (fig. 1, photos 1, 4, 5, and 6).

The coastal storm of early March 1962, the most devastating extratropical storm on record, caused severe erosion at locations between Long Island and Cape Hatteras (table 1). The property damage associated with this storm was in excess of $200 million (Cooperman and Rosendal, 1962). Property damage shown in photos 1 and 4 (fig. 1) taken at Virginia Beach, Va., and Fire Island, N.Y., are representative of the severe beach erosion between Long Island and Cape Hatteras. Photo 3 (fig. 1) depicts the severe erosion experienced by coastal states north of New York caused by the storm of February 19 and 20, 1972. The February 9 and 10, 1973, storm caused major to severe erosion along the coasts of Maryland, Virginia, and North Carolina. Photo 6 shows the erosion along the North Carolina coast which was associated with this storm. Damage at Plum Island, Mass., (photo 2) was associated with the mid-March storm of 1976. The severe erosion at Ocean City, Md., (photo 5) occurred just a few months ago in December 1977.

Storms with large erosion potential can occur each year. The number and intensity of erosion events varies from place to place along the coast. However, on the average, the New England coast experiences about two erosion events each winter season (November through April). For this same time period, the remainder of the East Coast experiences about one event every two seasons. As for intensity of erosion (minor, moderate, major, and severe), the coastlines

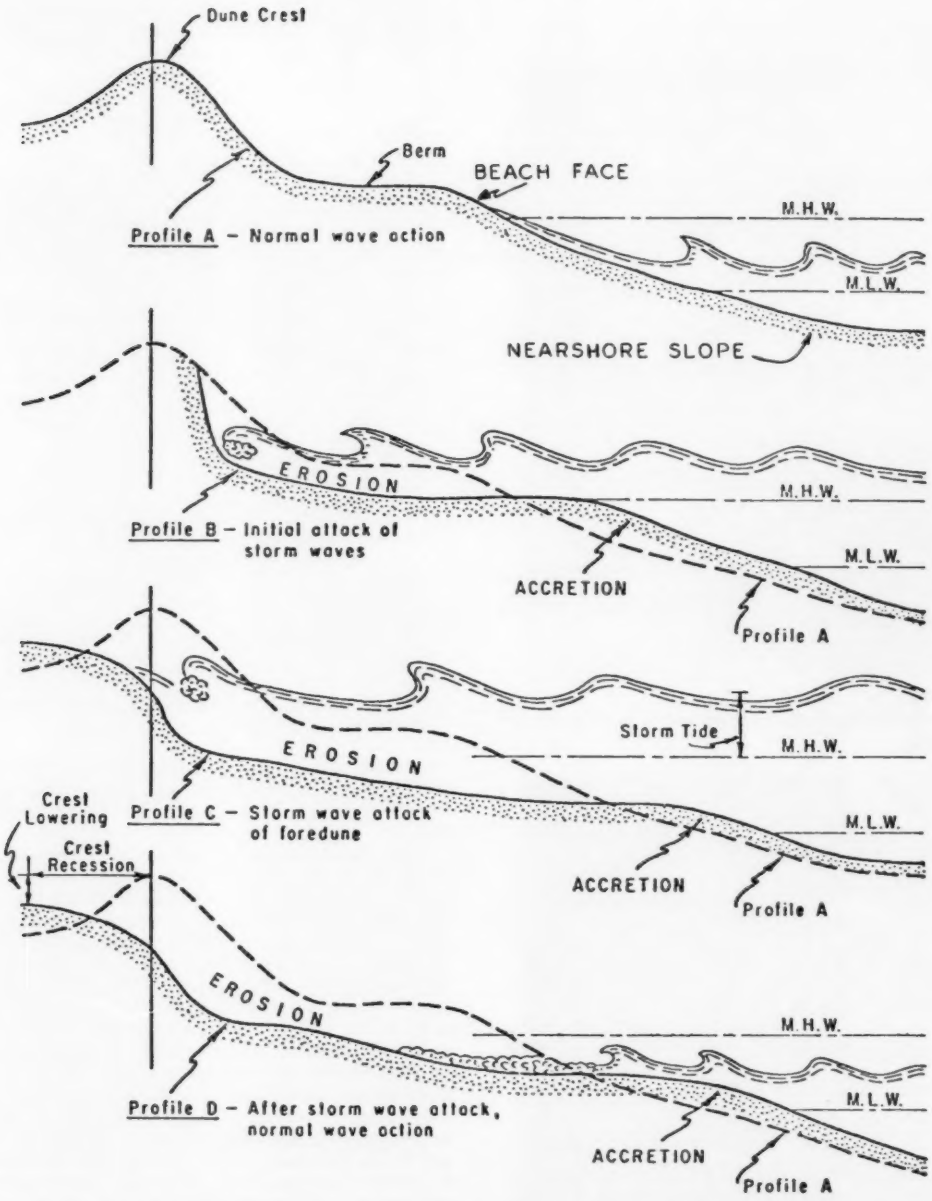

Figure 3.--Schematic diagram of storm wave attack on a beach (modified from U.S. Army Coastal Engineering Research Center, 1973).

of New York and Virginia have severe erosion about once every five seasons. The coastline of the other East Coast states experiences severe erosion about half as often or about once in every 10 seasons (Richardson, 1977).

CAUSES OF STORM-RELATED EROSION

Beach erosion is a complex process involving many oceanographical, meteorological, and geological factors. Some of the more important factors are winds, tides, waves, and breakers. Most of these factors must be considered in combination with one another. For example, the phase of the astronomical tide at the time of the meteorologically produced water level (storm surge or storm tide) is important. If the storm surge occurs at the time of high astronomical tide, the water above the nearshore slope (fig. 3) will be higher, and the nearshore slope will have

less effect (refraction and shoaling) on the incoming waves. These wind-waves (large heights and small periods) will break high on the beach face because of the superelevated water level of the combined high astronomical tide and storm surge. Steep wind-waves place a large quantity of water on the beach in a short time. This large amount of water does not have enough time to percolate through the beach face. Thus, the runback of each wave on the beach face carries away more sand than is brought to the beach by the runup of the next wave. The beach face migrates landward, cutting a steep slope into the berm (fig. 3). This landward cutting is responsible for damage to coastal structures shown in the photographs in figure 1.

The length of time (duration) that steep waves break high on the beach face is also another important factor in the erosion process. The March 1962 storm with its large storm surge and steep waves remained in the same area for five successive high tides. The long duration of this storm allowed steep waves to break high on the beach face for a long period of time. The long duration contributed significantly to the severe erosion associated with the March 1962 storm.

Most storms move large amounts of sand from the beach to areas offshore, but after storms the lower waves and swell with long periods that follow tend to restore the sand to the beach face. Depending on the availability of updrift sand for restoration, a storm may result in little permanent change.

Storm path and wave direction are important factors in determining the amount of material moved alongshore. If a storm causes a direction of alongshore transport opposite to the long-term direction of transport, then the sand will be returned in the months after the storm and permanent beach changes will be small. If the direction of transport before, during, and after a storm is the same as the long-term direction of transport, then large amounts of material removed by the storm have little possibility of being restored (U.S. Army Coastal Engineering Research Center, 1973).

MAN'S RESPONSES

Man has responded to changing shorelines in two ways. Along some shorelines, he has attempted to restore, stabilize, and protect beaches. To aid in this task he has constructed groins--low stone walls built at regular intervals along a beach to retard sand movement. On the side of the groin towards which sand is moving, the beach is widened, but the beach down-current is usually narrowed unless particular care is taken in constructing and placing the groin. Another approach to beach stabilization is replenishment, a procedure whereby large volumes of sand are brought in and put on the beach. In some instances this sand is dredged from shallow protected bays behind beaches. At best, both of these restoration and stabilization procedures can only stall nature, shorelines will continue to change.

Man's other response has been to turn to "beach management." Rather than build permanent structures on these zones of changing sand, "at the water's edge," these beaches have been set aside for state and national parks, to be enjoyed by all. In other words, let nature take its course.

SUMMARY

Our beaches will be revisited by storms with large erosion potential such as the March 1962 storm. However, the tremendous shoreline changes and damage caused by these storms, which are long remembered by man, are erased from the memory of the beach by winds and the never-ending tides and waves. Yes, our beaches will continue to accrete, erode, and be shaped as they have for thousands of years.

REFERENCES

Cooperman, A.I., and H.E. Rosendal, 1962, "Great Atlantic coast storm," Climatological Data, National Summary, 13(1), U.S. Department of Commerce, 137-145.

Richardson, W.S., 1977, "Forecasting beach erosion along the oceanic coastlines of the northeast and mid-Atlantic states," M.A. Thesis, Virginia Institute of Marine Science, 121 pp.

U.S. Army Coastal Engineering Research Center, 1973, Shore Protection Manual, 1, Fort Belvoir, Va., 495 pp.

THE MARINERS WEATHER LOG WELCOMES ARTICLES AND LETTERS FROM MARINERS RELATING TO METEOROLOGY AND OCEANOGRAPHY, INCLUDING THEIR EFFECTS ON SHIP OPERATIONS.

Mariners Weather Log

A CASE OF WINTER SEASON HURRICANE-FORCE WINDS OFF THE U.S. EAST COAST

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Hurricane-force winds are sometimes encountered in the ocean areas off the U.S. East Coast in the winter. On January 19, 1977, the USNS VICTORIA encountered unusually high winds on a trip from Europe to Charleston, S.C. At 1300 the ship was near 32°N, 72°W, and experiencing sunny skies and calm winds. By 1500 the winds had increased to 40 kn. The captain reported that the onset of high winds began as a black squall. By 1900 the winds reached 50 to 60 kn with gusts to 75 kn and were accompanied by thunderstorms with hail and snow showers. The swells were high and came at short intervals, swamping the main deck several times.

The VICTORIA had passed through a cold front prior to 1300, and at 1300 it was in an area of weak surface gradient to the west of the front. Figure 4 shows the surface analysis for January 19 at 1200. The position of the ship at 1300 is marked by an "X". The visible GOES-1 photograph for 1330 shows the band of cloudiness associated with the front extending from A to B (fig. 5). Also shown in figure 5 are the breaks in the cloud cover (C) around the ship (X) and an area of convective cloudiness (D) outlined by arrows.

The 1530 GOES-1 visible picture (fig. 6) shows the VICTORIA (X) under the leading edge of the area of convective clouds (D). The effect of cold air moving

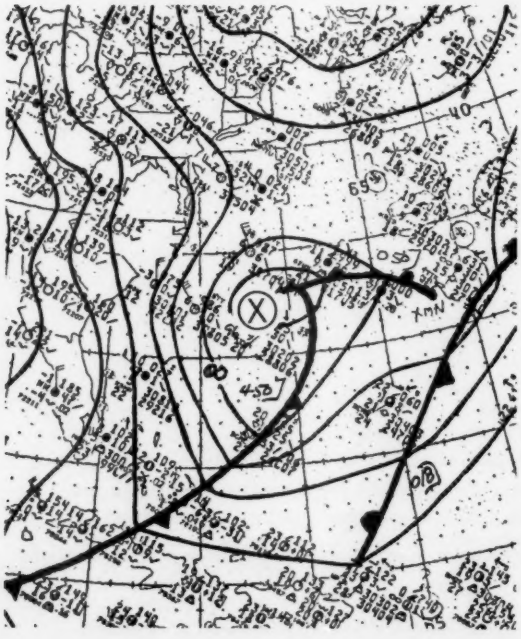

Figure 4.--Surface chart for 1200 January 19, 1977.

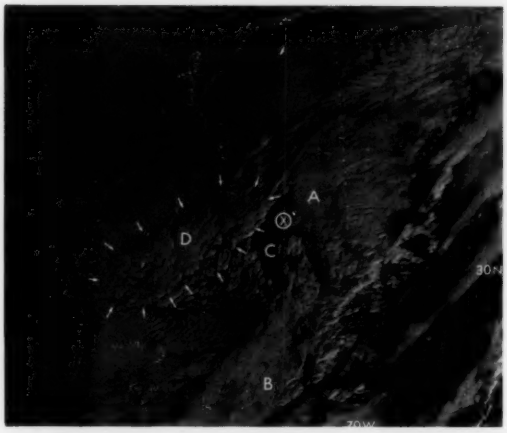

Figure 5.--GOES-1 visible picture, 1330 January 19, 1977.

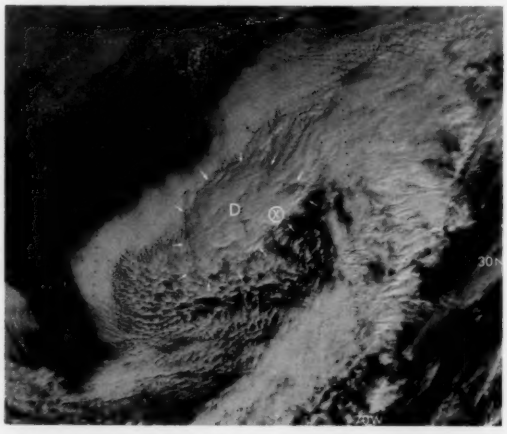

Figure 6.--GOES-1 visible picture, 1530 January 19, 1977.

over warm water enhanced the convective activity. This cloud development is frequently seen in winter off the U.S. East Coast. In this case, extremely cold air, with surface temperatures in the Carolinas and Georgia as low as -14°C, was moving out over the warmer 18° to 22°C water of the Gulf Stream. An enormous amount of heat was being added to the lower layers of the atmosphere. This in conjunction with very cold temperatures aloft made the air mass unstable and caused strong convection and turbulent mixing through a deep layer of the atmosphere. At 1200 the ship KSNP reported 50-kn winds in the thunderstorm area (D) (fig. 5).

Figure 7.--Surface chart for 1800 January 19, 1977.

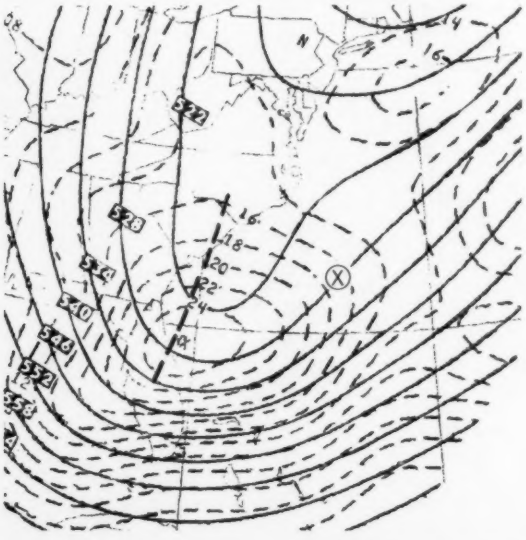

Figure 8.--Analysis at 500 mb, 1200 January 19, 1977. Solid lines are height contours, dashed lines are vorticity.

The surface low (fig. 4) deepened 4 mb in the succeeding 6 hr as it moved northward (fig. 7). The deepening surface low tightened the gradient in the vicinity of the VICTORIA and helped to increase the surface windspeeds. At 500 mb a trough was analyzed just offshore at 1200 (fig. 8). The 500-mb (20,000 ft) wind at Charleston, S.C., increased from 22 to 81 kn between 1200 and 2400 on this day. The wind direction remained at 320° as the 300-mb jet stream moved over Charleston. The increase in windspeed aloft over the area of the ship had the effect of increasing the surface wind. This occurred as the convective activity brought the stronger winds from aloft down to the surface.

By 1630 (fig. 9) the convective area (D) showed more organization. At 1830 (fig. 10) it showed a

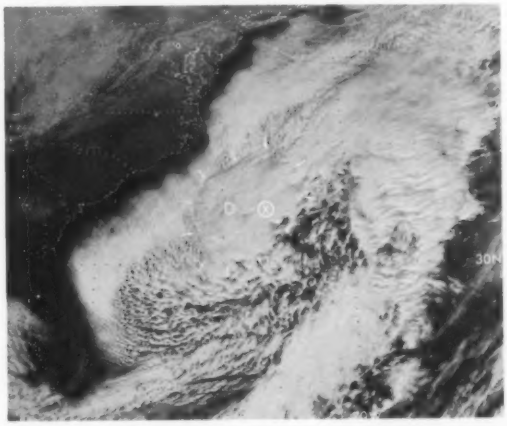

Figure 9.--GOES-1 visible picture, 1630 January 19, 1977.

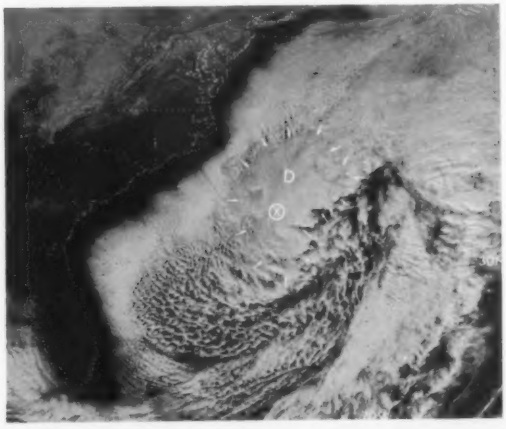

Figure 10.--GOES-1 visible picture, 1830 January 19, 1977.

definite cyclogenetic configuration of the convective area (D). It was at this time that the VICTORIA was experiencing winds gusting to hurricane force.

A summary of the observations taken by the VICTORIA follows: 1300 - position 32°08'N, 72°20'W; heading 295 at 15 kn; winds calm; sea-level pressure (SLP) 993 mb; 1500 - SLP 990 mb; wind 340/40 kn; 1700 - SLP 992 mb; wind 340/40, gusts to 60 kn; thundershowers with hail and snow; 1900 - SLP 997; wind 340/50 to 60, gusts 70 to 75 kn; very short interval swells with swamping of the main deck.

In this case, a well-defined area of convective activity associated with a very strong area of upward vertical motion moved off the coast ahead of a trough aloft. Combined with this was the effect of cold air moving over much warmer water. The sharp increase in wind velocities that were experienced under this synoptic situation could have been anticipated to some extent. Certainly, forecasts of higher winds could be made when the well-defined center of convective activity was seen developing in the satellite photographs.

ACKNOWLEDGMENTS

I would like to thank George Yount, Meteorologist in Charge at Charleston, who brought the VICTORIA's observations to my attention. Thanks also to Frances Parmenter, Ralph Anderson, LaRue Amacher, and Sheila Collin for their help.

WE OF NOAA ARE MAKING USE OF THIS SMALL AMOUNT OF SPACE TO EXTEND OUR THANKS TO ALL THE SHIPS' OFFICERS WHO ROUTINELY TAKE SHIPBOARD WEATHER OBSERVATIONS. TO US THESE EXCELLENT OBSERVATIONS ARE PRICELESS. WE CERTAINLY DO APPRECIATE RECEIVING THEM ON A REGULAR BASIS.

EASTERN NORTH PACIFIC TROPICAL CYCLONES, 1977

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National Weather Service, NOAA
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Tropical cyclone activity over the eastern North Pacific in 1977 began on May 25 and ended October 23. Spanning 152 days, the 1977 season was 2 days longer than the 1976 season. Table 2 shows the monthly distribution of cyclone activity, and tables 3 and 4 compare this activity with that of recent years. The 1966-77 period was chosen for comparison since it probably includes all tropical cyclone activity in the area owing to the excellent satellite coverage during that period. Prior to 1966 some cyclone activity was undetected because of the sparsity of data. A summary of the important features of the 1977 season is given in table 5. Cyclone tracks are shown in figure 11.

Although there were nearly as many tropical cyclones in 1977 (17) as there were in 1976 (18), only 47 percent of the 1977 cyclones reached tropical storm or hurricane intensity compared with 78 percent of the 1976 cyclones. The number of tropical cyclones reaching storm or hurricane intensity in 1977 was 47 percent less than the 1966-76 average. The highest sustained windspeed in 1977 was 90 kn. During the 1976 season 63 percent of the hurricanes had winds 100 kn or greater and the highest sustained speed was 125 kn. The duration of hurricane-force winds in 1977 totaled 128 hr compared with 498 hr in 1976. Storm winds in 1977 totaled 343 hr and those in 1976 816 hr.

The 1977 tropical cyclone season was exceptional in that one of the hurricanes, Doreen, became the second such storm within a year to bring heavy rains to southern California. The previous hurricane, Kathleen in 1976, was the first tropical cyclone to hit southern California since 1939.

Tropical cyclone advisories were issued by the Eastern Pacific Hurricane Center four times daily on a regularly scheduled basis at 0300, 0900, 1500, and 2100. During the 1977 season 193 advisories were issued compared with 393 during the 1976 season. This is a decrease of 51 percent from 1976, a season with only one more cyclone and 2 less days.

Although numerous merchant and fishing vessels passed close to the centers of tropical cyclone activity during the 1977 season and undoubtedly experienced heavy weather and seas, no reports of casualties or damage were received from them. Several ships near the origin of tropical storm Glenda on September 23 reported 70-kn winds and 25- to 35-ft seas, but no reports of damage or casualties were received.

All of the tropical cyclones during 1977 dissipated at sea. As a result damage was considerably less than in 1976 when several cyclones moved onshore

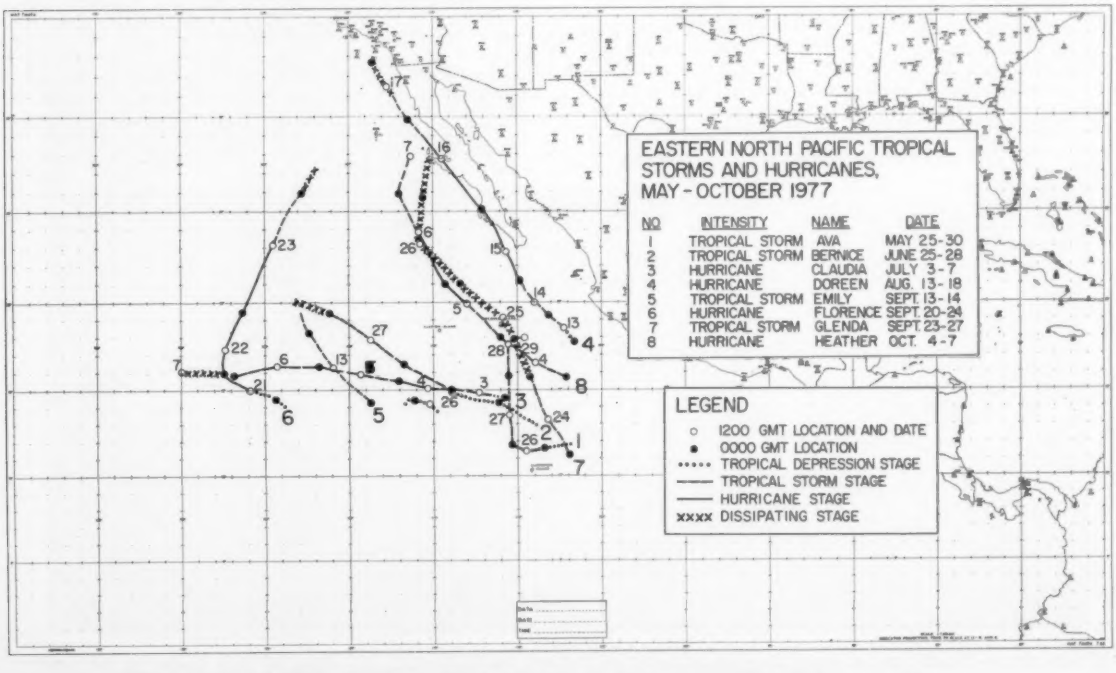
EASTERN NORTH PACIFIC TROPICAL STORMS AND HURRICANES, MAY - OCTOBER 1977
NO INTENSITY NAME DATE
1 TROPICAL STORM AVA MAY 25-30
2 TROPICAL STORM BERNICE JUNE 25-28
3 HURRICANE CLAUDIA JULY 3-7
4 HURRICANE DOREEN AUG. 13-18
5 TROPICAL STORM EMILY SEPT. 13-14
6 HURRICANE FLORENCE SEPT. 20-24
7 TROPICAL STORM GLENDA SEPT. 23-27
8 HURRICANE HEATHER OCT. 4-7
LEGEND
1200 GMT LOCATION AND DATE
0000 GMT LOCATION
TROPICAL DEPRESSION STAGE
TROPICAL STORM STAGE
HURRICANE STAGE
xxxx DISSIPATING STAGE

Figure 11.--Tracks of eastern North Pacific tropical storms and hurricanes, 1977.

Table 2.--Monthly distribution of eastern Pacific tropical cyclones, 1977 *

	May	June	July	August	September	October	November	Total
Tropical depressions	1	1	3	1	2	1	0	9
Tropical storms	1	1	0	0	2	0	0	4
Hurricanes	0	0	1	1	1	1	0	4
Total	2	2	4	2	5	2	0	17

*Cyclones are ascribed to the month in which they began.

Table 3.--Frequency of eastern Pacific tropical storms and hurricanes combined by months and years *

Year	May	June	July	August	September	October	November	Total
1966	0	1	0	4	6	2	0	13
1967	0	3	4	4	3	3	0	17
1968	1	1	4	8	3	3	0	19
1969	0	0	3	2	4	1	0	10
1970	1	3	6	4	1	2	1	18
1971	1	1	7	4	2	2	1	18
1972	1	0	1	6	2	1	1	12
1973	0	3	4	1	3	1	0	12
1974	1	3	3	6	2	2	0	17
1975	0	2	4	5	3	1	1	16
1976	0	2	4	4	3	1	0	14
1977	1	1	1	1	3	1	0	8
Total	5	20	41	49	35	20	4	174
Average	0.4	1.7	3.4	4.1	2.9	1.7	0.3	14.5

*Cyclones are ascribed to the month in which they began.

Table 4.--Number of eastern Pacific tropical storms reaching hurricane intensity by months and year *

Year	May	June	July	August	September	October	November	Total
1966	0	1	0	4	2	0	0	7
1967	0	1	0	2	1	2	0	6
1968	0	0	0	3	2	1	0	6
1969	0	0	1	1	1	1	0	4
1970	1	0	1	1	0	1	0	4
1971	1	1	0	6	2	1	0	12
1972	1	0	0	6	1	0	0	8
1973	0	1	3	0	2	1	0	7
1974	0	2	2	4	2	1	0	11
1975	0	1	2	3	1	1	0	8
1976	1	2	1	2	1	1	0	8
1977	0	0	1	1	1	1	0	4
Total	3	9	16	29	18	10	0	85
Average	0.3	0.8	1.3	2.4	1.5	0.8	0	7.1

*Cyclones are ascribed to the month in which they began.

before dissipating. Although hurricane Doreen dissipated offshore, the heavy rains it brought into southern California resulted in extensive damage to much of the area. Doreen moved northward along the Baja California coast roughly along the same track as hurricane Kathleen had taken in 1976 (fig. 12). Aside from this the two cyclones differed in many ways. As Doreen

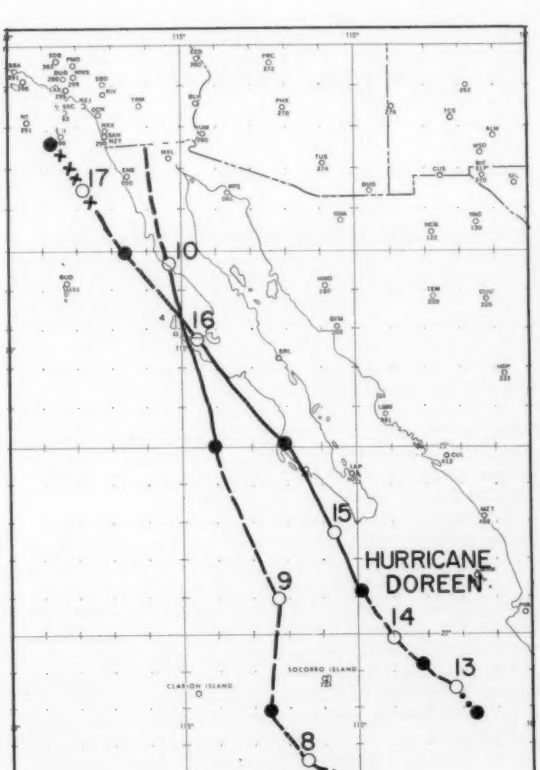

Figure 12.--A comparison of the tracks of Doreen (August 1977) and Kathleen (September 1976).

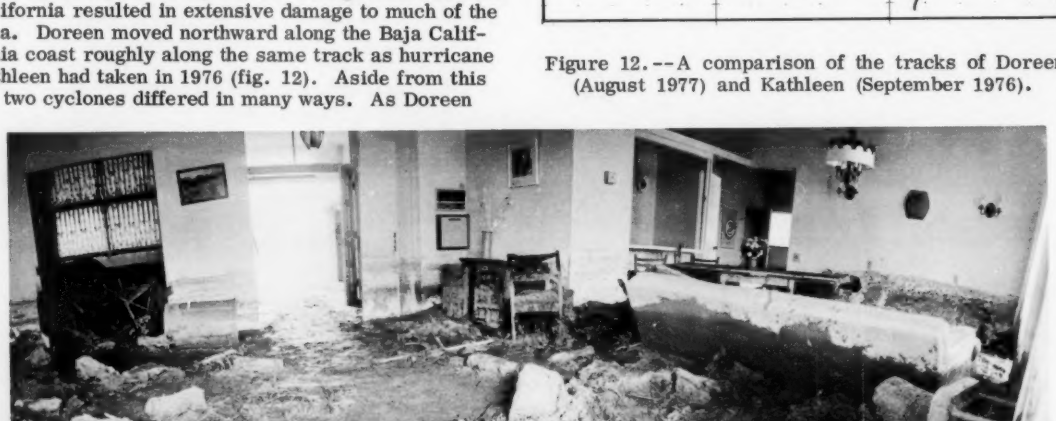

Figure 13.--Flood waters from Doreen carried rocks and mud through the door of this home in Borrego Springs in southern California. Los Angeles Times Photo.

Figure 14.--Kathleen's runoff gouged a hole in this California highway.

approached southern California it slowed, weakened considerably, and remained offshore. Kathleen accelerated to 33 kn as it approached California, maintained its intensity, and turned inland over the southern desert areas. Kathleen moved rapidly through the area, Doreen lingered. Kathleen concentrated its heaviest rain over the mountains and dry washes along the eastern slopes of the coast range. Doreen's precipitation was more widespread and concentrated over the low-lying areas including those west of the coastal mountains. San Diego reported 1.00 in of rain with Kathleen and 2.13 in with Doreen (fig. 13). East of the coast range, Imperial reported 2.22 in with Kathleen and 3.87 in with Doreen. In the higher mountains, Mt. Wilson, north of Los Angeles, had a storm total of 10.78 in with Kathleen and 2.61 in with Doreen. Damage from Kathleen was due mostly to flash flooding and rapid runoff (fig. 14). With Doreen damage was mostly from standing water, especially in the agricultural areas of the Imperial Valley where precipitation was heavier than with Kathleen (fig. 15).

There were no deaths in the United States directly

Figure 15.-- Rescue worker hangs over the rampaging Los Angeles River. The river bed is usually dry, but the rains of Doreen rapidly changed its character. Los Angeles Times Photo.

Table 8.--Eastern North Pacific tropical cyclones - 1977 (All date/times GMT, latitudes north, longitudes west.)

Cyclone	Lifespan	Depression	Storm	Hurricane	Storm	Depression	Final Position	Highest Sustained Wind From	To	Kt
Tropical storm Ava	25 May-30 May	251500 11.8-107.0	261200 11.5-109.6			291800 18.0-110.0	301200 18.0-110.2	281200 17.8-110.7	281800 17.9-110.3	55
Tropical cyclone Two	30 May-1 Jun.	301800 12.1-87.8					010000 13.2-89.0	311200 13.2-89.0	010000 13.2-89.0	30
Tropical cyclone Three	9 Jun.-11 Jun.	091800 13.2-92.5					110000 14.8-95.2	100000 14.0-93.0	100600 14.5-93.7	30
Tropical storm Bernice	25 Jun.-28 Jun.	251500 13.0-109.0	261200 15.0-114.0			280000 19.6-121.4	280600 20.1-123.4	261800 15.6-115.9	270600 17.1-117.7	40
Hurricane Claudia	3 Jul.-7 Jul.	030000 14.5-110.9	030600 14.8-111.7	040345 15.2-114.4	050000 15.5-117.0	070000 16.0-127.1	071200 16.2-130.0	040600 15.2-114.7	041800 15.4-116.1	80
Tropical cyclone Six	8 Jul.-9 Jul.	080000 13.6-117.0					090600 16.3-123.0	080600 14.2-118.2	090600 16.3-123.0	30
Tropical cyclone Seven	9 Jul.-10 Jul.	090000 13.4-105.2					100000 13.0-106.6	090000 13.4-105.2	100000 13.0-106.6	30
Tropical cyclone Eight	25 Jul.-25 Jul.	250000 11.8-135.0					251200 11.8-136.5	250000 11.8-135.0	251200 11.8-136.5	25
Tropical cyclone Nine	1 Aug.-2 Aug.	011600 15.4-127.1					021200 14.8-131.2	020600 15.8-130.1	021200 14.8-131.2	30
Hurricane Doreen	13 Aug.-18 Aug.	130000 17.6-106.5	131800 18.8-107.7	141800 20.3-109.3	160600 26.4-113.2	170600 30.7-117.0	180000 33.0-118.6	141800 20.3-109.3	160600 26.4-113.2	65
Tropical cyclone Eleven	3 Sep.-4 Sep.	031200 21.5-105.5					041200 21.1-111.0	040000 21.0-109.0	041200 21.1-111.0	30
Tropical storm Emily	13 Sep.-14 Sep.	130000 14.0-118.8	130600 14.9-120.0				140600 19.5-123.0	130600 14.9-120.0	140600 19.5-123.0	35
Tropical cyclone Thirteen	19 Sep.-23 Sep.	191200 17.0-109.4					230000 25.0-114.5	200000 17.6-112.4	220000 23.0-116.5	30
Hurricane Florence	20 Sep.-24 Sep.	201800 13.9-124.2	211800 15.1-126.9	220000 15.8-127.8	231200 23.2-124.8	240000 26.2-122.8	240600 27.4-122.3	221800 17.9-127.3	230600 21.2-125.7	90
Tropical storm Glenda	23 Sep.-27 Sep.		232100 10.7-106.5			250000 15.5-109.2	270600 27.8-115.2	232100 10.7-106.5	240600 12.0-107.5	60
Hurricane Heather	4 Oct.-7 Oct.	040000 15.3-107.2	040600 15.8-108.2	050600 18.8-112.1	061800 24.8-116.8	071200 27.9-116.4	071200 27.9-116.4	051200 20.0-113.2	060000 20.9-114.3	75
Tropical cyclone Seventeen	22 Oct.-23 Oct.	220500 14.0-115.0					230600 14.0-116.2	220500 14.0-115.0	221800 14.6-115.6	30

Figure 16.--One of the highways washed out by the heavy rains of Doreen. Los Angeles Times Photo.

attributable to Doreen. Flood waters destroyed 325 homes and businesses in the southern desert areas, and several people were evacuated from low-lying areas. The small desert town of Ocotillo was flooded again as it had been during hurricane Kathleen. Buses sent to evacuate people from Ocotillo returned empty,

however, when the townspeople declined to leave their small community. Interstate Highway 8 at Myers Creek, west of Ocotillo, was washed out again (fig. 16), and two of the four lanes of Interstate Highway 15 between Los Angeles and Las Vegas were undercut by flood waters. Damage to agricultural interests in San Diego and Imperial counties was estimated to exceed $25 million.

The National Environmental Satellite Service Field Station, colocated with the Eastern Pacific Hurricane Center, provided excellent satellite coverage during the 1977 tropical cyclone season. Several movie loops were available each day as well as visual and infrared data at 30-min intervals from the stationary SMS 2 (Synchronous Meteorological Satellite) and polar-orbiting NOAA 5 satellite. The detail on the satellite imagery was excellent with full disk resolution at 4 mi and sector resolution at 2 mi with 1/2 mi resolution available on request. Especially useful were the H-curve "enhanced" pictures from infrared imagery depicting the upper level cold centers of the tropical cyclones. The gridding of satellite pictures was accurate to within a few miles due to the stability of the satellite (SMS2) over the Equator and easily visible landmarks. Cyclone intensity was calculated using the Dvorak technique of satellite cyclone analysis (Dvorak, 1973).

The U.S. Air Force made four reconnaissance flights into eastern Pacific tropical cyclones during the 1977 season and NOAA aircraft made one flight. The first flight, with two penetrations, was made into tropical storm Ava on May 28 when the storm was 310 mi south of the tip of Baja California. A second flight was made into Ava, with one penetration, on May 29 with the storm now 275 mi south of Baja. This was 2-1/2 mo before the next reconnaissance flight was made into hurricane Doreen. The flight was made on August 14, with two penetrations, when the hurricane was about 150 mi south of the tip of Baja California. The fourth flight, with one penetration, was made into hurricane Doreen on the following day (August 15), when the cyclone was about 15 mi off the west coast of extreme southern Baja California. The fifth and final flight of the 1977 season was made into Heather, when the hurricane was off the tip of Baja California on October 5.

While satellite imagery continues to improve and is probably one of the most important tools used by the tropical forecaster today, aircraft reconnaissance and synoptic surface ship reports retain their importance as invaluable comparative observations for both the tropical forecaster and satellite meteorologist.

The average forecast error during the 1977 season was slightly greater than that of 1976.

Several computer-derived tropical cyclone forecast tracks for the eastern North Pacific were available from the National Hurricane Center in Miami during the 1977 season. The forecasts included a simulated analog model (CLIPER), a statistical synoptic model (EPHC77), an analog model (EPANALOG), and a barotropic model (SANBAR). The Hovermale, or Limited Fine-Mesh Movable Grid model was available on request from the National Meteorological Center. Table 6 shows the average forecast error computed by the Scientific Services Division, NWS Western Region Headquarters, for each of the models during the 1977 season. Included is the average forecast error for the Eastern Pacific Hurricane Center (EPHC). Of the computer-derived models, EPHC77 was the most reliable. The forecasters at the EPHC improved upon the computer tracks in all forecast periods.

Table 6.--Forecast errors

(Number of cases/average error in nautical miles)

Forecast period	24 hr	48 hr	72 hr
EPHC Forecasters	61/126	24/239	7/284
EPANALOG	56/141	30/265	12/365
EPHC77	52/129	27/255	10/292
CLIPER	56/129	30/255	12/378
SANBAR	12/137	8/271	3/508

TROPICAL STORM AVA - May 25-30

The first tropical cyclone of the 1977 season began as a tropical disturbance at 0600 May 24 500 mi south-southwest of Acapulco, Mexico. Centered near 9.5°N, 103.5°W, the disturbance was embedded in a broad band of convective activity extending westward from Panama and Costa Rica. Moving northwestward at 8 kn the distrubance began to slowly intensify. By 1500 on the 25th, satellite imagery indicated circulation about the center and the disturbance was upgraded to a tropical depression near 11.8°N, 107°W, or 500 mi southwest of Acapulco. Turning westward, the depression continued to intensify. By 1200 on the 26th winds had increased to 40 kn near the center, and the depression was upgraded to tropical storm Ava near 11.5°N, 109.6°W. At 1800 the tanker CHEVRON AMSTERDAM passed through the center of Ava reporting light variable winds, air temperature of 77°F, and sea surface temperature of 82°F. Figure 17 shows Ava at

Figure 17.--Tropical storm Ava SMS 2 (1/2 mi resolution at 1845 May 26. The tanker CHEVRON AMSTERDAM near the center at 11.6°N, 110°W, at 1800 reported light variable winds.

about that time. The storm then turned sharply to the north under the influence of an upper level trough that was moving across Baja California and northern Mexico. Continuing to intensify over the relatively warm water, Ava reached its maximum intensity of 55 kn at 1200 on the 28th near 17.8°N, 110.7°W, or 60 mi south-southeast of Socorro Island (fig. 18). At 2337 Air Force reconnaissance located the center of Ava with a poorly defined eye at 17.8°N, 109.9°W. No longer under the influence of the upper level trough moving across northern Mexico, Ava slowed to a nearly stationary position at 18°N, 110°W. A second reconnaissance flight through the storm at 1735 on the 29th located the center near 18.2°N, 110°W. The eye, which was now better defined, was open to the south. Surface winds 40 mi from the center were estimated near 30 kn. Winds on Socorro Island, 60 mi to the northwest, were northerly at 35 kn. The cargo ship, THOMPSON LYKES, 80 mi east-southeast of Ava, reported southwesterly 15-kn winds. Ava was downgraded to a tropical depression at 1800 on the 29th with the center still near 18°N, 110°W. Flow aloft at 200 mb had weakened and became more westerly. The deep-layer circulation between 1000-100 mb had also weakened and shifted from the southwest to the northwest. Lacking upper level support and with sea-surface temperatures cooling to 75°F, the depression began to slowly dissipate. The cyclone was downgraded to a tropical disturbance after 1200 on May 30 with the center near 18°N, 110.2°W.

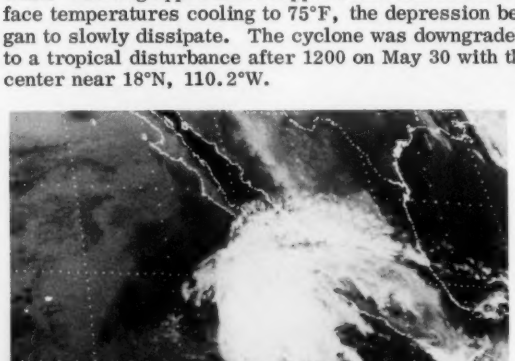

Figure 18.--Tropical storm Ava infrared SMS 2 imagery at 1215 May 28. The center near 17.8°N, 110.7°W, had 55-kn winds.

TROPICAL STORM BERNICE - June 25-28

Bernice began as a tropical disturbance 500 mi southwest of Acapulco, Mexico, at 0000 on June 25. Centered within an area of convective activity 600 mi in diameter, the disturbance moved west-northwestward at 11 kn over 81°F water. By 1500 satellite imagery indicated cyclonic circulation about the center, and the disturbance was upgraded to a tropical depression near 13°N, 109°W, or 580 mi west-southwest of Acapulco. Continuing on a west-northwesterly track, the depression began to slowly intensify. By 1200 on June 26 winds had increased to 35 kn, and the depression was upgraded to tropical storm Bernice near 15°N, 114°W, or 560 mi southwest of the tip of Baja California. By 1800 the storm had moved to 15.6°N, 115.9°W, and winds near the center had increased to 40 kn. Bernice then turned northwestward and began to weaken over 78°F water. By 0600 on the 27th winds had decreased to 35 kn. Low clouds to the north began to feed into the low-level circulation (fig. 19), further weakening the cyclone. By 1800 the center of the storm was near 19.1°N, 120.1°W, or 620 mi west-southwest of the tip of Baja California. It then turned west-northwestward and by 0000 on the 28th with winds near 30 kn was downgraded to a tropical depression near 19.6°N, 121.4°W. The final advisory on the cyclone was issued at 0600 on June 28 with the center dissipating rapidly near 20.1°N, 123.4°W. Although satellite imagery continued to show cyclonic circulation in the low-level cloud field for an additional 24 hr, all convective activity associated with the cyclone had ceased, and winds near the surface had decreased to 20 kn or less.

Figure 19.--Visible satellite picture showing tropical storm Bernice at 1715 June 27 with 35-kn winds near the center at 19.1°N, 120.1°W.

HURRICANE CLAUDIA - July 3-7

The fifth tropical cyclone of the season began at 0000 on July 1 as a disturbance centered near 12.1°N, 100.4°W, or 280 mi south of Acapulco. Embedded within an area of convective activity 400 mi in diameter, the disturbance moved westward at 12 to 14 kn over 84°F water. By 0000 on the 3d satellite pictures showed cyclonic circulation about the center, and the disturbance was upgraded to a tropical depression near 14.5°N, 110.9°W, or 250 mi south of Socorro Island and 670 mi west of Acapulco. Winds near the center were 30 kn and increasing. Slowing to 8 kn the depression continued to move west over 81°F water. By 0600 winds had increased to 45 kn, and the depression was upgraded to tropical storm Claudia with the center near 14.8°N, 111.7°W. Visual satellite pictures at 1800 July 3 showed Claudia with a small eye about 15 mi in diameter. Figure 20 shows the cyclone at 2145. By 0000 July 4 Claudia had moved to 15.1°N, 114°W, and winds near the center had increased to 55 kn. The cargo ship PACIFIC

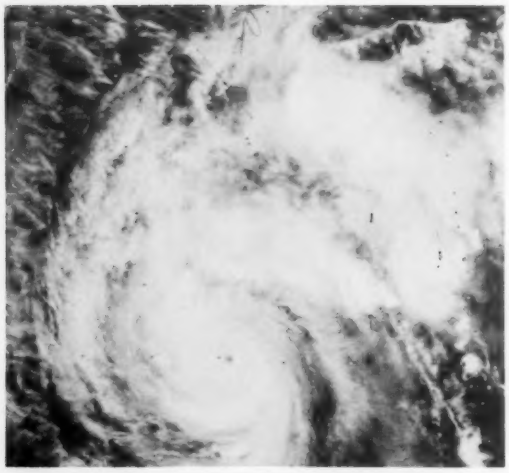

Figure 20.--Tropical storm Claudia SMS 2 (1/2 mi resolution) visible satellite picture at 2145 July 3 near 15°N, 113.8°W. The storm intensified to a hurricane 6 hr later near 15.2°N, 114.4°W.

ERA, 200 mi to the north, helped to locate the center of the storm. By 0345 Claudia's winds had increased to 70 kn, and the storm was upgraded to a hurricane near 15.2°N, 114.4°W. Winds increased to 80 kn by 0600 with the center now 300 mi southwest of Socorro Island. Infrared satellite imagery at 0600 and 1200 seemed to show trochoidal motion associated with the center of the cyclone. At 0545 on July 4 Claudia's eye appeared to be centered near 15.4°N, 114.7°W. Thirty minutes later at 0615, the eye appeared near 15.1°N, 114.6°W. Again at 1145 infrared imagery showed the eye near 14.9°N, 115.2°W, shifting to 15.3°N, 115.3°W, at 1215. Claudia continued to move west at 8 kn and began to slowly weaken over 78°F water. Winds near the center decreased to 60 kn by 0000 on July 5 and the hurricane was downgraded to a tropical storm near 15.5°N, 117°W, or 400 mi southwest of Socorro Island. The eye was no longer visible from satellite pictures. Continuing to move westward, Claudia increased its speed to 13 kn. The tanker CHEVRON CALIFORNIA, the cargo ship INGER, and the NOAA research vessel OCEANOGRAPHER were helpful in locating the center of Claudia as it continued westward. By 1800 on the 6th the storm had moved to 16.3°N, 126°W, and winds near the center had decreased to 35 kn. The storm continued to weaken with sea-surface temperature near 76°F. Claudia was downgraded to a tropical depression with 30 kn winds near the center at 0000 on the 7th near 16°N, 127.1°W. The final advisory was issued at 1200 on the 7th with the center rapidly dissipating near 16.2°N, 130.0°W. The SILVERMAIN, 25 mi northeast of the dissipating cyclone, reported only 10-kn winds. Remnants of Claudia continued to drift westward for an additional 36 hr before completely dissipating near 15°N, 140°W.

HURRICANE DOREEN - August 13-18

Doreen began as a tropical distrubance 100 mi west of Acapulco, Mexico, at 0000 on August 11. Ship reports along the Mexican coast helped to locate the disturbance. Reports from the ARGO LEADER, MALMROS MONSOON, ROLLNES, MEADOWBANK, PRAG, and LYNTON GRANGE were especially helpful. Drifting west at 6 kn, the disturbance was upgraded to a tropical depression at 0000 on August 13 with the center near 17.6°N, 106.5°W, or 400 mi west of Acapulco. The cyclone then turned northwestward and began to slowly intensify over 82°F water. By 1800 winds had increased to 45 kn and the depression was upgraded to tropical storm Doreen near 18.8°N, 107.7°W, or 460 mi west-northwest of Acapulco. At 1742 on the 14th, Air Force reconnaissance located the center of Doreen near 20.3°N, 109.3°W, or 160 mi south of the tip of Baja California. A second penetration of the storm was made at 1958. Based on extrapolated sea-level pressure (979 mb), the storm was upgraded to hurricane Doreen with 65-kn winds near the center. The eye, open to the southwest, was 15 mi in diameter. Reports from the STAR MALMANGER, OGDEN JORDAN, ALBANY, MARITIME RELIANCE, and TEMPLE INN helped to confirm satellite and reconnaissance positions.

Turning to the north-northwest and increasing its speed to 9 kn, Doreen passed 30 mi west of the tip of

Figure 21.--SMS 2 visible satellite picture of hurricane Doreen at 1716 on August 15 near 23.5°N, 110.7°W. Winds were 65 kn near the center.

Baja California at 1300 on the 15th. Figure 21 shows Doreen near the tip of Baja California. By 1800 the hurricane had moved to 23.6°N, 110.8°W, or about 15 mi off the west coast of extreme southern Baja. The cargo ship EXPORT BUYER, 120 mi southeast of Doreen at 1800, reported southerly 45-kn winds, moderate rain, 16-ft wind-waves, and 24-ft swells resulting in combined seas of 29 ft. Another ship, the TEMPLE INN 260 mi southeast of Doreen, reported southeasterly 40-kn winds with 22-ft wind-waves. The Air Force made another reconnaissance flight through Doreen at 1820 on the 15th, reporting the eye with a

closed wall 10 mi in diameter no longer open to the southwest. Turning more to the northwest and increasing its speed to 18 kn, Doreen drifted onshore briefly near San Carlos on the west coast of southern Baja. By 0000 on the 16th, the center was near 25°N, 112°W. The ARTHUR MAERSK, 80 mi to the northwest, helped to locate the center. As Doreen moved northwestward over cooler 72°F water, the hurricane began to weaken. By 0600 the winds had decreased to 50 kn and the hurricane was downgraded to a tropical storm near 26.4°N, 113.2°W. Drifting onshore again, Doreen moved to the tip of the Point Eugenia Peninsula by 1200. By 1300 the storm was again offshore moving northwestward over the Bay of Sebastian Vizcaino. Winds near the center had decreased to 35 kn over water that was now near 68°F. The DANWOOD ICE, 30 mi northeast of Doreen, reported east-southeasterly 32-kn winds. Winds near the center of Doreen continued to decrease as the storm drifted toward the southern California coast. By 0600 on the 17th Doreen's winds had decreased to 30 kn and Doreen was downgraded to a tropical depression near 30.7°N, 117°W, or 130 mi south of San Diego. By 1800 the cyclone was 70 mi southwest of San Diego and winds had decreased to 25 kn. With satellite imagery showing weak low-level cyclonic circulation, the final advisory on the depression was issued at 0000 on August 18, with the center near 33°N, 118.6°W, or 25 mi north-northwest of San Clemente Island off the southern California coast. Remnants of Doreen then drifted slowly northeastward across southern California.

While Doreen was off the central Mexican coast and still south of Baja California, another disturbance was developing near 15°N, 119°W, and it began to drift eastward into the cyclonic flow associated with Doreen. Ships within 300 mi of this new disturbance reported moderate to heavy rain. As Doreen moved northward along the Baja California coast, this moisture was carried northward around Doreen and into southern California. This moist tropical air began to enhance shower and thundershower activity over the southern California desert areas on August 15. Flash flood watches and warnings already in effect for heavy thundershowers over the Colorado River Valley and eastern desert areas, were extended along with heavy rain warnings for most of southern California by the 16th.

Rain moving northward with Doreen reached San Diego early on August 16, spreading northward to the Los Angeles Basin and Mojave Desert by afternoon, and the Owens Valley and southern San Joaquin Valley by evening. On the coast, rain reached as far north as Santa Barbara by early the following morning. The rain continued over southern California through late evening on the 17th, and a few showers lingered in the Los Angeles area until late morning on the 18th. An average of 2 to 4 in of rain fell over the low-lying areas of southern California during the 3-day period and as much as 7.5 in fell in the higher mountains. In addition to storm totals noted earlier, 2.47 in were reported at the Los Angeles airport, 3.78 in at Calexico, and 7.45 in at Mt. St. Jacinto, west of Palm Springs. An unusually heavy amount of 6 in was reported at Mitchell Caverns, 60 mi west of Needles on August 17.

TROPICAL STORM EMILY - September 13-14

Emily, the 12th tropical cyclone of the 1977 season, began as a disturbance near 11.2°N, 113.6°W, at 0000 on September 12. Moving west-northwestward over 83°F water, the disturbance began to intensify. By 0000 on the 13th it was upgraded to a tropical depression near 14°N, 118.8°W. At 0500 the tanker HERCULES, 200 mi east of the cyclone, reported southeasterly 35-kn winds and a sea-surface temperature of 87°F. At 0600 the depression was upgraded to tropical storm Emily near 14.9°N, 120°W. Moving across a pocket of cool 77°F water, the storm began to weaken under an impressive "bursting pattern" in which cyclonic energy was converted to upward vertical motion and a spectacular outflow of high-level clouds. Figure 22 shows the burst near its maximum. Turning north-northwestward over 79°F water, Emily began to weaken rapidly after losing much of its energy in the bursting process. By 0600 on the 14th, the center had moved to 19.5°N, 123°W. The FUJISAN MARU, 90 mi to the west-northwest, reported north-northeasterly 30-kn winds. Turning northward, Emily dissipated rapidly over 77°F water.

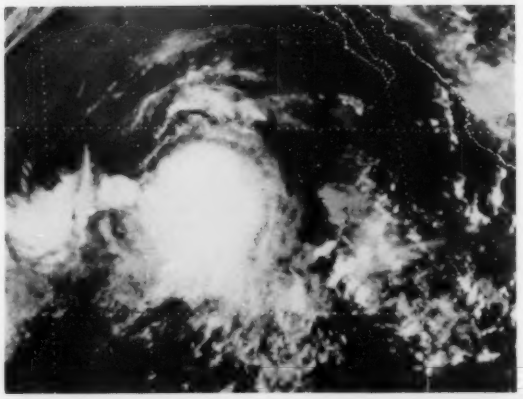

Figure 22.--SMS 2 infrared satellite image showing tropical storm Emily at 1215 September 13 with maximum high-level cloud outflow after "burst." The center with 35-kn winds was near 16.1°N, 121.1°W.

HURRICANE FLORENCE - September 20-24

While depression thirteen was turning northwestward 180 mi west of Socorro Island, a new disturbance was beginning to develop 600 mi to the southwest near 12.8°N, 123°W. Turning northwestward and moving at 8 kn over 82°F water, the new disturbance intensified rapidly. Within 12 hr the disturbance was upgraded to a tropical depression near 13.9°N, 124.2°W, at 1800 on September 20. The cyclone then turned west-northwestward and continued to intensify over 84°F water. By 1800 on September 21, winds near the center had increased to 55 kn, and the cyclone was upgraded to tropical storm Florence near 15.1°N, 126.9°W. Six hours later the winds had increased to 65 kn, and the storm was upgraded to a hurricane near 15.8°N, 127.8°W. Florence then turned to the north, slowed to 6 kn, and continued to intensify, reaching a maximum intensity of 90 kn at 1800 on the 22d near 17.9°N, 127.3°W. The hurricane developed a well-defined eye as shown in figure 23. Turning to the north-northeast and accelerating to 18 kn over considerably colder 74°F water, the

Figure 23.--Visible SMS 2 satellite picture at 1715 September 22 showing hurricane Florence with 90-kn winds near the center at 17.9°N, 127.3°W. Tropical depression 13 can be seen to the northeast dissipating near the Baja California coast.

hurricane began to weaken rapidly. By 1200 on the 23d, the winds had decreased to 60 kn and Florence was downgraded to a tropical storm near 23.2°N, 124.8°W. Florence was now moving over 71°F water at 22 kn and dissipating rapidly. By 0000 on the 24th winds had decreased to 30 kn, and the cyclone was downgraded to a tropical depression near 26.2°N, 122.8°W. The final advisory on the cyclone was issued at 0600 on September 24 with the center dissipating near 27.4°N, 122.3°W, or about 390 mi west of the central Baja California coast.

TROPICAL STORM GLENDA - September 23-27

As Florence was accelerating to the north-northeast and rapidly dissipating, a new disturbance was beginning to take form 550 mi southwest of Acapulco near 9.5°N, 105.5°W. Moving northwestward at 8 kn over 86°F water, the disturbance began to intensify. The first real indication of its true intensity came at 2100 on September 23, when Scripps Institution of Oceanography reported to the Eastern Pacific Hurricane Center that several ships near 10°N, 106°W, were experiencing 70-kn winds and 25- to 35-ft seas. Based on ship reports and satellite imagery, which was beginning to show cyclonic circulation near the center, the disturbance was upgraded directly to tropical storm Glenda at 2100 with the center near 10.7°N, 106.5°W. Figure 24 is an enhanced infrared satellite image of the area about 3 hr after the initial ship reports. Turning to the north-northwest and increasing its speed to 12 kn, Glenda moved to 15.5°N, 109.2°W, by 0000 on September 25. The tanker GRAND OPAL, 160 mi to the northeast, was reporting east-southeasterly 15-kn winds and satellite pictures were beginning to show the beginnings of a bursting pattern. The storm was downgraded to a tropical depression at 0000 on the 25th. Increasing its forward speed to 20 kn, the depression moved to 19°N, 110.9°W, or 10 mi north of Socorro Island by 1200. Winds on the island were west-northwesterly at 10 kn. Moving under the west side of an upper low centered over northern Mexico, the depression moved to 20°N, 112.1°W, by 1800. The upper outflow of clouds resulting from the bursting process appeared to be at a maximum and extended to a diameter of 300 mi. Continuing north-northwestward the cyclone moved to 23.2°N, 115.8°W, by 1200 on the 26th. It then turned northward and began to dissipate rapidly over 72°F water. The final advisory on the cyclone was issued at 0600 on September 27 with the center at 27.8°N, 115.2°W, or near the tip of the Point Eugenia Peninsula midway up the west coast of Baja California.

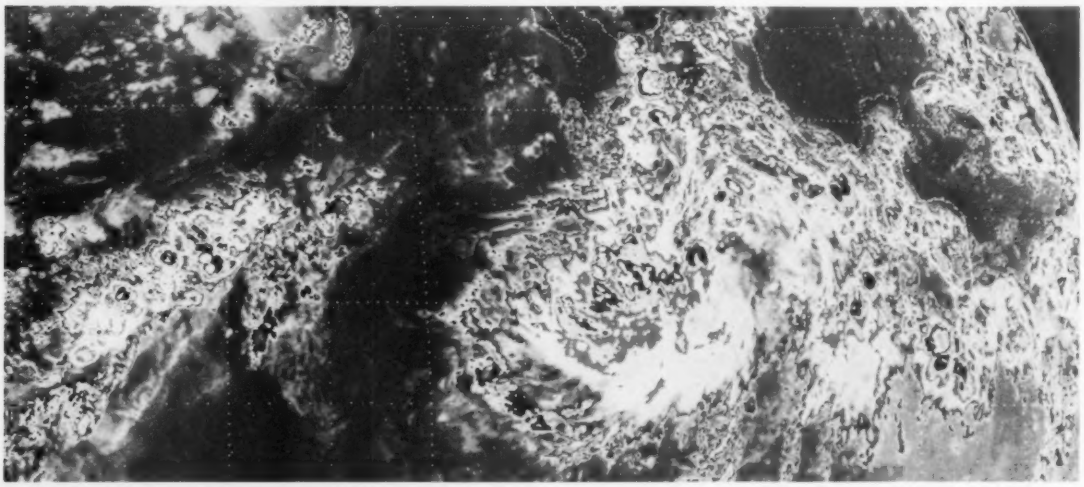

Figure 24.--Enhanced infrared satellite imagery showing tropical storm Glenda at 2345 September 23 near 11.0°N, 106.8°W. Several ships near the center reported 70-kn winds and 25- to 35-ft seas.

Figure 25.--Hurricane Heather SMS 2 infrared imagery at 0615 October 5. The center was near 19°N, 112.3°W, with 65-kn winds. Winds increased to a maximum of 75 kn 6 hr later.

HURRICANE HEATHER - October 4-7

The 16th cyclone of the 1977 season began as a tropical disturbance near 15.1°N, 106°W, at 1800 on October 3. Moving westward at 12 kn over 84°F water, the disturbance began to intensify and was upgraded to a tropical depression near 15.3°N, 107.2°W, at 0000 on the 4th. The LEVIN FISHER and CHARLEROI were helpful in determining the center of the cyclone. Turning northwestward with winds increasing to 35 kn, the depression was upgraded to tropical storm Heather 6 hr later near 15.8°N, 108.2°W. As Heather moved northwestward and continued to intensify, the UNION CONCORD, MARITIME LEADER, and PACIFIC helped to locate the center of the cyclone. At 0000 on the 5th, the NELSON MARU, 120 mi north-northeast of the cyclone, reported east-southeasterly 34-kn winds. By 0600 winds near the center of Heather had increased to 65 kn, and the storm was upgraded to a hurricane near 18.8°N, 112.1°W, or 60 mi west of Socorro Island (fig. 25). Winds on the island at 0600 were from the southwest at 50 kn. By 1800 Heather had moved to 20.5°N, 114°W, and the winds near the center reached their maximum of 75 kn. Winds on Socorro Island, now 200 mi to the southeast, had shifted to the southeast at 25 kn. The MIYAGO MARU, 60 mi north of the cyclone, was reporting easterly 50-kn winds, and the MORMACSTAR, 190 mi to the northeast, was reporting southeasterly 30-kn winds. At 2100 NOAA reconnaissance aircraft estimated sea-level pressure near the storm at 978 mb indicating a surface wind of about 65 kn. Turning to the north-northwest over 77°F water, Heather began to weaken. By 1800 on the 6th, winds had decreased to 45 kn, and Heather was downgraded to a tropical storm near 24.8°N, 116.8°W, or 250 mi west of Puerto Magdalena on the west coast of southern Baja California. The storm then turned northward over 72°F water and began to weaken rapidly. By 0000 on the 7th the center was at 25.9°N, 117°W, or about 150 mi southwest of the tip of Point Eugenia. As Heather moved toward the Baja California coast, the ships EUROASIA CONCORDE, RYOKO MARU, and GURANKA were especially helpful in locating the center of the cyclone. Satellite imagery began to show a separation of about 120 mi between the upper and lower circulations associated with the cyclone, although both continued to drift northward toward Point Eugenia at about the same speed, 10 kn. The final advisory on the cyclone was issued at 1200 on October 7 as the storm was downgraded to a rapidly dissipating depression near 27.9°N, 116.4°W, or 80 mi west of Point Eugenia on the Baja California coast.

REFERENCES

Dvorak, Vernon F., 1973, "A technique for the analysis and forecasting of tropical cyclone intensities from satellite pictures," NOAA Tech. Memo., NESS 45, U.S. Dept. Commerce, NOAA, Washington, D.C., 19 pp.

Mariners Weather Log

GREAT LAKES NAVIGATION SEASON, 1977

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Washington, D.C.

There was a break in continuous traffic through the Great Lakes system this calendar year for the first time in 3 yr. Extreme cold weather in December and January resulted in the closing of the ore trade from Lake Superior through the St. Marys River on January 21 (fig. 26), and it did not reopen until March 15. A few ships carrying vital fuel continued to operate, but only with constant icebreaker assistance. Lake Ontario with its depth was the only lake that escaped vast amounts of ice. Lakes Michigan and Erie became completely ice covered for the first time in many years.

The Soo Locks closed and did not reopen until March 18, except for an emergency passage by two Canadian tankers accompanied by the Canadian icebreaker GRIFFON in February. The first American oreship to pass through the Soo Lock on March 18 was the CALLAWAY.

Heavy ice cover on the Welland Canal and St. Lawrence Seaway delayed the planned opening date to April 13, but unusually warm weather during March allowed that date to be advanced to April 4. The previous earliest opening was March 25, 1975. The first upbound vessel in the Seaway at Montreal was the Norwegian cargo ship THORSHOPE. The eastbound traffic was led by the Canadian laker LAWRENCECLIFFE HALL, which transited the Iroquois Lock bound for Pointe Noire.

At the Welland Canal the first through passages were made by two 730-ft Canadian freighters, the MANITOULIN upbound and the QUETICO downbound. On April 11 overseas traffic began with the passage of the Japanese freighter HAMANASU bound for Toledo. During April 60 oceangoing vessels passed upbound into Lake Erie.

The Canadian lock at Sault Ste. Marie opened to traffic on April 18 about a week later than normal. It is reported that this facility will be closed to commercial shipping within the next 5 yr. The shorter length, width, and depth of the lock is leading to its demise. The maximum length for vessels permitted to transit the largest lock, the Poe in the Soo Canal of the St. Marys River, was increased to 1,100 ft.

Fourteen vessels were under construction or on order at U.S. shipyards, 10 for the Lakes. Three new ships were christened or nearing completion, the

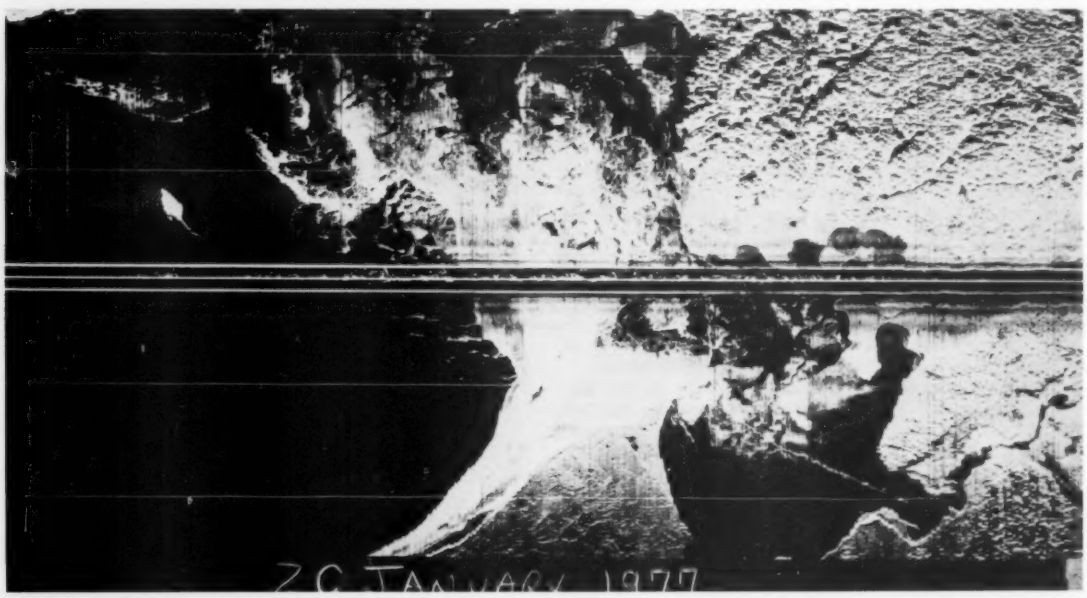


Figure 26.--A Side-Looking Airborne Radar image of the ice on eastern Lake Superior and Whitefish Bay on January 20, 1977. The next day the Soo was closed to shipping for the first time in 3 yr. The white trackline through the center of the Bay results from the high reflectivity of small pieces of brash ice.

Figure 27.--MESABI MINER, 1,000 ft long, passes Detroit's Renaissance Center enroute to christening at Duluth. Photo by Albert G. Ballert.

MESABA MINER (fig. 27), BELLE RIVER, and BURNS HARBOR.

The official closing date for entering the St. Lawrence Seaway was scheduled for December 15, and December 30 for the Welland Canal. Some day-to-day extensions are always anticipated, but the delay until December 26 was prompted partly by the need to get the U.S. polar icebreaker NORTHWIND into the Lakes to replace the damaged sistership WESTWIND (fig. 28). They were the last inbound and outbound vessels passing each other in the U.S. section near Massena, N.Y., on Christmas Day.

The last commercial vessel through the Seaway was the Swiss-registered ST. CERGUE (fig. 29), which cleared the St. Lambert Lock at Montreal also on the 26th. This was 2 days later than the previous closing. The late exodus of ocean ships was slowed by adverse weather, including poor visibility due to snow, persistent fog, and high winds. There were still 71 ships above the U.S. Seaway locks after December 15, the official closing date.

The last upbound passage by a cargo vessel was the A.H. FERBER (fig. 30), which entered the Iroquois Lock on December 24 bound for Lorain, Ohio. The last ocean freighter upbound was the Brazilian JOANA. Actually, another salt-water vessel, the ESPERANCE III, entered on December 8, but it will remain on the Lakes as a dredger.

Transits of the Welland Canal ended with the upbound Canadian LOUIS R. DESMARAIS on December 30. Navigation through the Canadian lock at Sault Ste. Marie was concluded on December 9. The Poe Lock

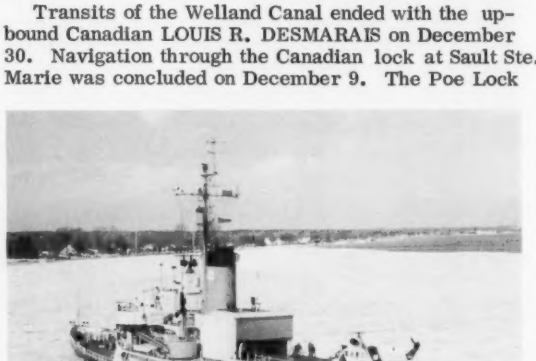


Figure 28.--The Coast Guard icebreaker WESTWIND operating in the St. Clair River. The damaged icebreaker was replaced by the NORTHWIND for the 1977-78 winter. Coast Guard Photo.

Figure 29.--The Swiss ST. CERGUE was the last of the "salties" to transit the St. Lawrence Seaway, when it cleared St. Lambert Lock at Montreal ahead of the WESTWIND. It was a record-breaking outbound date of December 26. Photo by Albert G. Ballert.

Figure 30.--The A. H. FERBERT made the last upbound passage by a cargo vessel this season. The laker is shown here in the Poe Lock making a record late passage on February 8, 1973. Photo by Albert G. Ballert.

on the Soo Canal continued throughout the winter.

A new record size for ocean vessels transiting the Seaway into the Great Lakes was made by the Liberian-registered FEDERAL SCHELDE (fig. 31). There were 944 trips by ocean vessels into the Lakes originating from overseas ports by 551 vessels. The registry included 36 countries. The Seaway iron ore trade was at a record high as 936 lakers loaded 19,116,000 gross tons of ore at the three lower St.Lawrence ports.

Only Lakes Erie and St. Clair remained above the 1900-76 average level all year, but by December all were again above their average level. A review of precipitation data over the past decade reveals that there were above-average annual totals in 7 of the 10 yr in the Superior and Ontario basins, in 8 of the 10 yr in Michigan and Huron, and in all except 1971 in the Lake Erie basin. Table 7 shows annual precipitation data for 1972-77.

Table 7.--Annual precipitation data (in) for 1972-77

	Great Lakes	Lake Ontario	Lake Erie	Lake Huron	Lake Michigan	Lake Superior
1972	35.97	43.67	39.70	35.32	34.97	32.22
1973	33.87	38.16	37.01	33.34	33.98	30.84
1974	28.94	33.42	34.14	25.92	32.77	23.86
1975	34.62	38.53	38.95	34.58	35.74	29.81
1976	31.06	40.92	35.88	33.43	26.54	25.97
1977	38.84	44.26	42.79	37.04	34.42	39.93
Average 1900-77	31.68	34.61	34.02	31.44	31.33	29.73
Percent average	+23	+28	+26	+18	+10	+34
Record year	1977	1977	1977	1961	1959	1977
Record	38.84	44.26	42.79	39.03	37.82	39.93

NATIONAL WEATHER SERVICE AIDS

NOAA's National Weather Service (NWS) provided all routine weather services for the 1977 navigation season. Forecasts were provided for all 12 mo from Forecast Offices in Chicago, Detroit, and Cleveland. The Buffalo Forecast Office, which serves Lake Ontario and the St. Lawrence River international section, provided services during the navigation season from April through the end of the year. Fifteen other offices made nearshore marine forecasts during the recreational season from April to October. Radio dissemination of both routine and emergency weather information was made from NWS Weather Radio Stations in 17 cities. Lorain Electronics Corporation completed their automated VHF-FM communications system in September. Weather information was provided routinely

Figure 31.--The 730-ft FEDERAL SCHELDE is shown loading soybeans at Toledo, Ohio, in November 1977. She was the largest ocean vessel and the first of maximum size to transit the Seaway. Photo by Albert G. Ballert.

on these stations and three stations operated by Central Radio of Rogers City, Mich. Visual display stations around the Great Lakes shores were eliminated as radio signals became well established.

Two new NWS products were inaugurated during the 1977 season. In early fall a "Storm Coordination Bulletin" was established to provide concise and detailed data on major Great Lakes storms to mariners at 2- to 3-hr intervals. The Bulletins contain data on location, movement, and intensity of storms.

Radiofacsimile service was provided during the 1976-77 ice season. Ice charts as well as wind and temperature forecasts were transmitted daily. As in the previous years, the service ended as the spring ice melted. Service was resumed in December for the new ice season. Three new weather charts were developed for inclusion in the program. A surface chart analysis and 12- and 24-hr forecast analyses were transmitted twice daily. The new charts replaced the wind and temperature forecasts. Ice information remained basically the same. The weather portion of the radiofacsimile service was expected to continue year-round.

Table 8.--1977 Great Lakes warnings summary.

	Gale	Storm
Lake Superior	54	8
Lake Michigan	53	2
Lake Huron	50	3
Lake St. Clair	19	0
Lake Erie	45	4
Lake Ontario	19	1
St. Lawrence River	3	0
Totals	243	18

One gale warning was issued during each of the summer months in 1977. The total for all lakes combined was 243. Storm warnings were issued 18 times, with multiple occurrences in November and December (table 8).

ICE SEASON

The winter of the century continued unabated as calendar year 1977 began. The colder weather continued through the first week of February. A reversal to warmer weather was the rule through the spring, and the large amounts of ice observed in late winter melted nearly on a normal schedule through early May.

Record-breaking cold chilled most of the region on the last day of December 1976. In Cleveland, the mercury dropped to -11°F. Ice growth continued throughout the month with little letup in the severe cold. Temperatures on Lake Erie were over 13°F below normal for the month--an unprecedented departure. The eastern two-thirds of Lake Erie froze over completely, and ice jamming was reported in Lake St. Clair. By midmonth even the deepwater areas of the Upper Lakes were covered with ice, and 150 ships had been assisted.

A major outbreak of arctic air poured over the Lakes from Canada at midmonth with temperatures falling to new records. On January 16, it was -19°F in Chicago, 2°F below the old mark established in 1888. The coldest weather for the month, year, and in many cases for several decades was observed the following morning. Duluth, Minn., reported -18°F; in Ohio, Toledo reported -15°F and Cleveland -17°F.

On January 19 the Corps of Engineers in Chicago announced that industry had informed them that the worsening ice conditions and almost continuous ice-breaking assistance on Lake Superior and the St. Marys River had prompted them to temporarily suspend navigation. The winter energy shortage was also emerging

at that time, and unusual demands for Coast Guard assistance were being made for tankers. Rapid ice formation continued, and by the end of the third week, nearly 70 percent of Lake Superior was covered. Increasing ice pressure in Soo Harbor broke two moorings of the Little Rapids Cut ice boom. Some vessel delays resulted, but the Sugar Island ferry continued to operate. The last vessels moved through the locks at Sault Ste. Marie on January 21--the first break in continuous navigation on western Lake Superior in 34 mo.

February was the landmark month on the Lakes. For the first time since 1963 virtually all the Lakes except Ontario were ice covered. Milder temperatures combined with westerly winds finally arrived during the second week of February, and some of the thin ice cover in midlake areas dissipated. Quite a bit of open water appeared in western Lake Superior, southwestern Lake Michigan, and the western half of Lake Huron. On February 12 Buffalo noted the first day since the previous December 20 without any snowfall.

Colder weather during the third week of February resulted in considerable refreezing of previously open areas. By February 21 Lakes Superior, Michigan, and Huron had become nearly ice covered again (fig. 32). Some of the thinner ice melted by monthend.

Figure 32.--A LANDSAT image of central Lake Michigan on February 16. Resolution at the surface is 80 m from a height of 918 km. Ice extends from shore to shore.

The greatest concentration of ice cover on Lake Superior by the end of March was in eastern areas. Whitefish Bay and the lower St. Marys River remained covered. Ice on Lake Michigan was confined to the northern quarter from Green Bay through the Straits, and ice in Lake Huron continued to diminish.

Milder weather was widespread during the second week of April. Continued steady decay and gradual diminishing of ice cover was the rule.

For the second consecutive year, the Great Lakes were engulfed in very cold air through the fall season. The summer months were slightly colder than normal, and ice again formed generally earlier than usual. A strike in the mining industry of Minnesota and parts of Michigan eliminated most of the Great Lakes shipping from August into late fall. However, once the strike was settled many shipping companies pressed their ships into service well beyond their normal layup dates.

Temperatures averaged 2°F above normal over the Lakes during September and 2° to 4°F below normal in October. November began mild, but there was a rapid shift to below-normal temperatures by the last week. Parts of western Lake Superior reported temperatures as much as 15°F colder than usual.

Ice began to form in some back waters and harbors in early December. The joint U.S. Coast Guard-National Weather Service Ice Navigation Center opened for the season on December 10. The first icebreaking assistance to commercial shipping followed the next day, when the Coast Guard cutter KAW from Cleveland helped the GODERICH and a number of "salties" through the Detroit River. Not far away, a buoy tender helped the LEADALE in Saginaw Bay, and another assisted the SAGUENAY in Sandusky Bay.

The first routine Side-Looking Airborne Radar (SLAR) flight was launched on December 13 from Cleveland. Data showed ice had nearly covered southern Green Bay, western Lake Erie, and Lake St. Clair. Significant amounts of ice were also observed in the St. Marys River system, Saginaw Bay, and the Detroit River.

A major blow to icebreaking forces on the Lakes occurred on December 13. The polar icebreaker WESTWIND on her way to Sault Ste. Marie, Mich., from Milwaukee went aground at the mouth of the St. Marys River near Detour Light. Preliminary damage assessments showed major hull problems and plans were immediately put into action to replace her. The sister ship NORTHWIND was dispatched from her port in Baltimore on the 14th (fig. 33).

The St. Lawrence Seaway System closed on December 26. The WESTWIND on her way to Montreal for

Figure 33.--The NORTHWIND did not encounter ice on the Lakes this past winter to compare with the ice shown here in the Northwest Passage during the summer of 1969. U.S. Coast Guard Photo.

drydock repairs during the winter was the last outbound vessel. The NORTHWIND was the last inbound ship. Traffic was very heavy on the Seaway during December as a large number of foreign vessels made their final voyages. Some Canadian iron ore was also being shipped westward into the Lower Lakes until domestic ore was in plentiful supply after the U.S. strike.

By the end of the calendar year ice growth had covered almost all of Green Bay, Saginaw Bay, and Lake Erie west of the island chain. Significant ice cover also extended eastward to near Cleveland. New ice had formed around the southern end of Lake Michigan, and some floes were reported around the Apostle Islands, Duluth, and the northern bays of Lake Superior. The Coast Guard assisted 105 vessels by the end of the year.

GREAT LAKES OBSERVATION PROGRAM

There were 47 ships listed in the Great Lakes weather reporting program with 30 actually sending in reports. The total observations received at the National Climatic Center in Asheville, N.C., was 5,920--only slightly more than half those of 1976. The following number of observations by lake were reported: Lake Ontario, 15 by 3 ships; Lake Erie, 350 by 26 ships; Lake Huron, 1,731 by 29 ships; Lake Michigan, 846 by 24 ships; and Lake Superior, 2,978 by 29 ships.

Ships reported gales (34 to 40 kn) the following number of days: Lake Ontario, 0; Lake Erie, 10; Lake Huron, 19; Lake Michigan, 12; and Lake Superior, 16. Strong gales (41-47 kn) were reported 2 days on Lake Erie, 5 days on Lake Huron, 2 days on Lake Michigan, and 3 days on Lake Superior. Storm winds (48 to 55 kn) were reported on 2 days on Lake Huron and 1 day on Lake Superior. Violent storm winds (56 to 63 kn) were observed on 1 day on Lake Superior in September.

The most observations were made in May, closely followed by July and June. More high winds occurred in December followed by October and November. Table 9 shows high-wind observations by 10-kn categories.

Table 9.--Number of high-wind observations during calendar year 1977

High-wind categories	Observations
Over 30 kn	187
Over 40 kn	18
Over 50 kn	1

There were only 13 observations of seas over 12 ft and 1 of seas over 15 ft. December had the most days and observations with seas over 12 ft.

Tables 10 through 17 give summaries of the maximum winds for each lake by month, the highest wind by month on any lake, the highest 1-min wind by lake for each year since 1941, and the highest seas reported on each lake this year. The tables include only those observations that were logged on Great Lakes Observation Form 72-2 and forwarded to the National Climatic Center.

NOTABLE WEATHER HAPPENINGS

December led with both the most days and observations with high winds. September had the highest measured wind of 56 kn, which occurred on Lake Superior. The highest wave was 16.5 ft on December 1 on Lake Huron.

Of the 206 observations of winds over 30 kn there were only 7 reports of squalls or thunderstorms. There were four special observations sent at offtimes for severe weather, one involving a thunderstorm, one for hail, and two for gusting winds. Three of these were sent by the JOHN DYKSTRA (fig. 34). There were also four observations indicating lake ice. Ice accretion on ships did not appear to be a problem.

Figure 34.--A closeup view of the JOHN DYKSTRA during pleasant weather.

July had the greatest number of observations with visibility less than 2 mi, 186 or 16.8 percent of the total observations. May was second with 146 observations for 13.1 percent of the total.

Data and values for the winter months must be evaluated in terms of the few ships that were operating--therefore, few observations. Storms much more severe than indicated probably traversed the Lakes, but ships were not there to record the observations.

The following paragraphs describe by month some of the more severe storms as indicated by the observations. February and March are not included because of the sparsity of observations. Figure 35 shows the track of the center of the worst storm.

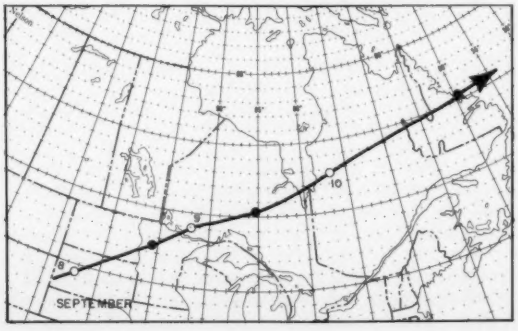


Figure 35.--Track of the only Great Lakes storm with winds greater than 50 kn. Open circles indicate the center at 1200 on date shown.

Table 10.--Maximum windspeed reported on Lake Ontario for each month by National Weather Service cooperating vessels, 1977

Month	Kn	Direction	Time (GMT)	Date	Ship	Lat. (°N)	Long. (°W)
January							
February							
March							
April				(No observations received)			
May							
June							
July							
August	10	240°	1800	04	ENDERS M. VOORHEES	43.5	78.2
September	26	320°	1800	14	ENDERS M. VOORHEES	43.8	77.0
October	16	360°	1800	02	ENDERS M. VOORHEES	43.6	78.0
November	24	340°	0600	13	JOHN DYKSTRA	43.5	78.5
December	24	320°	0000	10	JOHN DKYSTRA	43.6	77.1
Year	26	320°	1800	Sept. 14	ENDERS M. VOORHEES	43.8	77.0

Table 11.--Maximum windspeed reported on Lake Erie for each month by National Weather Service cooperating vessels, 1977

Month	Kn	Direction	Time (GMT)	Date	Ship	Lat. (°N)	Long. (°W)
January							
February				(No observations received)			
March							
April	32	260°	0600	28	CASON J. CALLAWAY	41.8	82.6
May	38	060°	0600	29	J. BURTON AYERS	42.3	80.3
June	32	250°	0000	02	CHAMPLAIN	41.9	82.6
	32	070°	1200	06	JOHN SHERWIN	41.9	81.5
July	31	350°	0600	26	J. BURTON AYERS	42.1	81.3
August	27	270°	0600	04	J. BURTON AYERS	42.7	79.3
September	32	260°	0000	27	G.M. HUMPHREY	41.9	82.5
October	41	160°	1200	08	G.M. HUMPHREY	41.9	82.7
November	38	280°	1800	28	G.M. HUMPHREY	42.7	79.6
December	44	240°	0000	02	SAMUEL MATHER	41.8	81.7
Year	44	240°	0000	Dec. 02	SAMUEL MATHER	41.8	81.7

Table 12.--Maximum windspeed reported on Lake Huron for each month by National Weather Service cooperating vessels, 1977

Month	Kn	Direction	Time (GMT)	Date	Ship	Lat. (°N)	Long. (°W)
January	26	270°	0600	06	ARTHUR M. ANDERSON	45.8	84.4
February	12	270°	1800	26	MACKINAW	45.2	83.1
March	30	070°	0000	29	ARTHUR M. ANDERSON	45.8	84.4
April	35	090°	1800	04	ARTHUR M. ANDERSON	45.8	84.5
	35	340°	0000	28	J. BURTON AYERS	44.7	83.0
May	42	330°	1800	08	J. BURTON AYERS	43.8	82.4
June	43	300°	1800	06	JOHN DYKSTRA	43.4	82.6
July	35	240°	1800	01	PAUL H. CARNAHAN	43.8	82.5
August	33	320°	0600	18	J. BURTON AYERS	45.3	81.3
September	42	100°	0000	25	G.M. HUMPHREY	45.1	82.2
October	48	140°	1200	08	JOHN DYKSTRA	43.6	82.0
November	48	320°	0600	26	CHAMPLAIN	44.8	83.1
December	42	120°	0000	09	ERNEST R. BREECH	44.3	81.8
Year	48	140°	1200	Oct. 08	JOHN DYKSTRA	43.6	82.0
	48	320°	0600	Nov. 26	CHAMPLAIN	44.8	83.1

Table 13.--Maximum windspeed reported on Lake Michigan for each month by National Weather Service cooperating vessels, 1977

Month	Kn	Direction	Time (GMT)	Date	Ship	Lat. (°N)	Long. (°W)
January	38	310°	1800	10	ENDERS M. VOORHEES	41.9	87.4
	38	170°	1800	13	PHILIP R. CLARKE	43.6	87.2
February	30	210°	0000	18	MACKINAW	45.7	85.8
March	25	070°	1800	28	CASON J. CALLAWAY	46.8	85.5
April	32	120°	1200	04	ARTHUR M. ANDERSON	45.8	85.8
May	28	190°	1800	23	CASON J. CALLAWAY	45.7	86.0
June	31	340°	0600	02	CHARLES M. WHITE	44.9	87.0
July	35	160°	1800	03	ARTHUR M. ANDERSON	44.6	86.7
August	34	180°	1800	12	ARTHUR M. ANDERSON	44.4	86.8
September	44	110°	1200	24	G.M. HUMPHREY	45.9	85.3
October	40	060°	1200	01	JOHN DYKSTRA	42.4	87.3
November	41	140°	1200	20	SAMUEL MATHER	43.3	86.7
December	38	320°	1200	06	J. BURTON AYERS	43.6	87.5
Year	44	110°	1200	Sept. 24	G.M. HUMPHREY	45.9	85.3

Table 14.--Maximum windspeed reported on Lake Superior for each month by National Weather Service cooperating vessels, 1977

Month	Kn	Direction	Time (GMT)	Date	Ship	Lat. (°N)	Long. (°W)
January	45	360°	0600	18	PHILIP R. CLARKE	47.4	86.5
February	20	100°	0600	23	MACKINAW	46.9	84.9
March	32	010°	0000	31	CASON J. CALLAWAY	47.8	88.8
April	38	010°	0600	28	JOHN DYKSTRA	46.9	86.0
May	36	340°	1200	08	PHILIP R. CLARKE	46.7	84.9
June	33	030°	1200	12	LEON FALK, JR.	47.0	85.7
	33	300°	1200	29	ENDERS M. VOORHEES	47.2	86.6
July	37	290°	0000	02	JOHN DYKSTRA	46.8	85.3
August	32	260°	0000	12	CLIFFS VICTORY	47.3	86.8
September	56	210°	1800	09	CHARLES M. BEEGHLY	47.4	88.9
October	37	010°	1200	06	J. BURTON AYERS	47.3	86.6
November	42	330°	1200	11	SAMUEL MATHER	48.0	89.2
December	48	110°	1800	17	G.M. HUMPHREY	48.0	89.3
Year	56	210°	1800	Sept. 09	CHARLES M. BEEGHLY	47.4	88.9

Table 15.--Maximum windspeed reported for each month for the Great Lakes by National Weather Service cooperating vessels, 1977

Month	Kn	Direction	Time (GMT)	Date	Lake	Ship	Lat. (°N)	Long. (°W)
January	45	360°	0600	18	Superior	PHILIP R. CLARKE	47.4	86.5
February	30	210°	0000	18	Michigan	MACKINAW	45.7	85.8
March	32	010°	0000	31	Superior	CASON J. CALLAWAY	47.8	88.8
April	38	010°	0600	28	Superior	JOHN DYKSTRA	46.9	86.0
May	42	330°	1800	08	Huron	J. BURTON AYERS	43.8	82.4
June	43	300°	1800	06	Huron	JOHN DYKSTRA	43.4	82.6
July	37	290°	0000	02	Superior	JOHN DYKSTRA	46.8	85.3
August	34	180°	1800	12	Michigan	ARTHUR M. ANDERSON	44.4	86.8
September	56	210°	1800	09	Superior	CHARLES M. BEEGHLY	47.4	88.9
October	48	140°	1200	08	Huron	JOHN DKYSTRA	43.6	82.0
November	48	320°	0600	26	Huron	CHAMPLAIN	44.8	83.1
December	48	110°	1800	17	Superior	G.M. HUMPHREY	48.0	89.3
Year	56	210°	1800	Sept. 09	Superior	CHARLES M. BEEGHLY	47.4	88.9

Table 16.--Highest 1-min wind (kn) reported on the Great Lakes by U. S. anemometer-equipped vessels

Year	Lake Erie		Lake Huron		Lake Michigan		Lake Superior		Lake Ontario	
1941	W	42	WSW	50	NW	43	NNW	54	--	--
1942	WSW	52	WSW	56	WNW	48	S	62	--	--
1943	WSW	57	WNW	43	SSW	50	WSW	52	--	--
1944	NE	38	NW	37	WSW	48	NNE	42	--	--
1945	WNW	52	SSW	54	WNW	49	NW	52	--	--
1946	SW	50	W	46	S	44	NW	47	--	--
1947	NW	51	SSE	43	ENE	39	WSW	43	--	--
1948	WSW	40	NNW	51	NW	45	WSW	48	--	--
1949	W	52	NNE	50	NNW	43	N	52	--	--
1950	SW	70	NW	48	NW	49	NW	81[1]	--	--
1951	WSW	37	WSW	50	SW	49	WSW	54	--	--
1952	SW	46	SW	57	SSW	44	WSW	45	--	--
1953	WSW	49	NW	45	NNW	46	ENE	50	--	--
1954	W	45	NW	45	E	48	N	43	--	--
1955	W	52	SW	57	WSW	58[1]	NW	48	--	--
1956	WSW	46	W	43	SSW	46	N	50	--	--
1957	WSW	72	SW	54	WSW	49	W	47	--	--
1958	SW	61	SW	43	SW	52	SSW	54	--	--
1959	W	42	NE	50	E	48	W	54	--	--
1960	NE	55	WSW	49	NW	55	N	54	--	--
1961	W	50	NW	47	NW	48	N	57	--	--
1962	NW	52	WNW	63	NW	48	NNW	60	--	--
1963	NNW	74[1]	NW	60	N	52	NNW	52	E	35
1964	WSW	68	W	72	NW	54	WSW	62	WNW	50[1]
1965	WSW	60	WNW	95[1]	ESE	52	SW	70	W	40
1966	ENE	49	NE	60	NW	57	NNE	61	W	39
1967	WSW	43	W	58	ENE	55	N	53	W	32
1968	W	63	NNW	44	WNW	46	NNE	55	SW	31
1969	WSW	44	NNW	46	NW	50	SSW	50	--	--
1970	W	52	W	62	NW	52	W	63	--	--
1971	SW	50	N	53	N	50	SW	56	--	--
1972	W	45	NW	56	N	54	NNE	60	--	--
1973	SW	45	ENE	44	NE	56	NE	50	--	--
1974	ENE	48	SW	47	SW	42	ESE	46	W	38
1975	NE	40	WSW	60	SW	54	W	50	NW	32
1976	W	48	S	56	NNW	55	NE	54	W	34
1977	WSW	44	SE	48	ESE	44	SW	56	NW	26

[1]Highest for each lake

JANUARY

This was a very rough weather month over the Great Lakes Basin. Not only was it very cold, but many places set new snowfall records and others had more snow than they had had for many years. As stated before, the Winter Demonstration Program had to cease operations on January 21.

The major storm of the month as far as high winds were concerned occurred only a few days before shipping through the Soo Locks ceased. The high winds were generated by a tight pressure gradient between a LOW that formed off Cape Cod and a HIGH over the high plains.

The LOW developed about 180 mi east of Cape Cod late on the 16th and moved northeastward off the New England coast. At 0000 on the 18th the 970-mb LOW was over Nova Scotia and a 1045-mb HIGH was centered over the North Dakota-Canadian border. Also, another small LOW appeared midway between James Bay and Lake Huron. At 0600 the PHILIP R. CLARKE measured 45-kn northerly winds on eastern central Lake Superior. She was the last of a convoy of four ore-laden American vessels to transit the Poe Lock until March 18. The seas at this time were 8 ft.

Although the coal shuttle from Toledo to Detroit continued until February 6 and resumed on the 21st, there were no further reports of winds greater than 30 kn. There were reports of low visibility mainly due to snow. A storm that traveled southeastward from northern Lake Winnipeg brought snow to the Lakes area on the 26th. The temperatures had been continually below freezing for many days over most

Table 17.--Highest seas reported on the Great Lakes by National Weather Service cooperating vessels, 1977

Lake	Ship	Date	Height (ft)
Ontario	ENDERS M. VOORHEES	September 24	8.0
Erie	CLIFFS VICTORY	December 25	14.5
Huron	CHARLES M. WHITE	December 1	16.5
Michigan	CHAMPLAIN	November 27	10.0
Superior	CHARLES M. BEEGHLY	September 9	14.5

of the area. Snow from 4 in to a foot blanketed the area, with winds blowing from 40 to 50 kn causing high drifts and bringing much of the area to a standstill. At Niagara Falls, N.Y., winds gusting to 65 kn were measured.

APRIL

April was a relatively quiet month. There were no winds greater than 38 kn measured by reporting ships on the Lakes.

The first storm to produce winds over 30 kn came out of the Oklahoma Panhandle. It moved over Missouri and Illinois on the 4th. While it was southwest of Chicago, the ARTHUR M. ANDERSON found winds over 30 kn while sailing from Lake Michigan into Lake Huron. At 1200 on the 4th winds were 32 kn from the southeast and at 1800 35 kn from the east. The storm (978 mb) moved over Lake Huron on the 5th, but there were no high-wind reports. This can be attributed partly to the few ships on the Lakes at this early date. The St. Lawrence Seaway and Welland Canal had just opened and ice on the Lakes and in the harbors was still a consideration. By the 7th the storm was over the Labrador coast.

From the 17th through the 22d near and record high temperatures were set in the area. On the 18th a record high of 88°F was set at Midway Airport. On the 19th Detroit set a new record of 83°F, and Buffalo had the warmest day since September 15, 1976. All was not well with shipping though as the warm air over the cold water caused dense fog. Between the 18th and 22d there were 32 reports of visibility less than 2 mi by 10 ships on Lakes Huron, Michigan, and Superior.

On the 27th a cold front running east-west between two large HIGHs moved southward over the Lakes. Small frontal waves were rippling eastward along the front. On the 27th and 28th there were five reports of winds over 30 kn on the four western lakes. The highest was 38 kn on Lake Superior measured by the JOHN DYKSTRA. On the 29th the center of the northern HIGH was over Lake Michigan with light winds.

MAY

May was notable for several items. It was the month that the most observations were submitted, the first thunderstorm with winds greater than 30 kn was reported by a ship, and May had the second highest number of low-visibility observations.

Late on the 7th a LOW formed west of James Bay and moved southeastward. At 1800 on the 8th its 1003-mb center was over Lake Ontario. A high-pressure center over Hudson Bay was pushing southward. At that time the J. BURTON AYERS was off Harbor Beach on Lake Huron with 42-kn northwesterly winds. The seas were 10 ft. The PHILIP R. CLARKE was sailing northwestward near the center of Lake Superior with 32-kn gales.

The storm had moved to New Jersey by 0000 of the 9th, and the CHARLES M. WHITE found 40-kn northerlies with 12-ft waves on Lake Huron. Later on the 9th, the WILLIAM A. REISS was off Ashtabula measuring 32-kn winds, and the J. BURTON AYERS was near Cleveland with 34-kn winds from the north. The LOW continued to move southeastward and deepened offshore, while the HIGH center moved over Lake Superior on the 10th.

The thunderstorms were reported by the JOHN DYKSTRA on Lake Superior first on a special observation at 0102 on the 9th while 28 mi northwest of Portage with 38-kn southeasterly winds, heavy rain, and hail. The synoptic report at 0600 also indicated thunderstorms while 36 mi west of Eagle Harbor.

A large HIGH was pushing slowly southward from northern Hudson Bay. An east-west-oriented cold front was pushed over the Lakes on the 29th. At 0600 the J. BURTON AYERS near Erie on Lake Erie had 38-kn northeasterly winds north of the front. The front continued southward to the Ohio River Valley. On the 31st a complex system of fronts, small LOWs, and HIGHs existed over the area with severe thunderstorms. Tornado watches were posted for parts of the Lower Lakes.

JUNE

A LOW formed on the lee side of the Rocky Mountains over Alberta, Canada, on the 4th. It moved southeastward and was centered near Wheeling, W.Va., at 1200 on the 6th at 998 mb. The wind flow over the Great Lakes varied from northerly to northeasterly. At the 1200 synoptic report three ships measured winds between 31 and 35 kn. They were the ELTON HOYT II and the G.M. HUMPHREY on Lake Huron and the JOHN SHERWIN on Lake Erie. At 1800 the CASON J. CALLAWAY had 31-kn gales on Whitefish Bay, and the JOHN DYKSTRA took the high-wind award for the month with 43-kn winds on lower Lake Huron. On the 7th the storm was moving to sea, and the pressure gradient relaxed.

JULY

This storm formed on June 29 east of the Rocky Mountains and traveled eastward just north of the Canadian border. At 1200 on the 1st the 985-mb center was about 300 mi north of Sault Ste. Marie with the front curving southeastward and southward to the eastern shore of Lake Ontario. Thunderstorms paralleled the front from the Mississippi Valley to the Great Lakes. A tornado damaged a shopping center in Sandusky, Ohio. Winds of 40 to 60 mi/h hit many areas in Michigan.

Ships on the Lakes were not so severely affected, but the highest wind of 37 kn measured for the month occurred with this storm. Also, 5 of the 11 reports of winds over 30 kn for the month were with this storm. The first report was by the ARTHUR M. ANDERSON on Lake Superior at 1200 on the 1st. The westerly 32-kn winds were associated with a squall. At 1800, the PAUL H. CARNAHAN measured 35-kn gales from 240° on Lake Huron. At 0000 on the 2d the JOHN DYKSTRA was north of Whitefish Point where she found the 37-kn winds from the west-northwest. Late on the 2d the LOW was absorbed by another center over Hudson Bay as a HIGH moved east along the Ohio River.

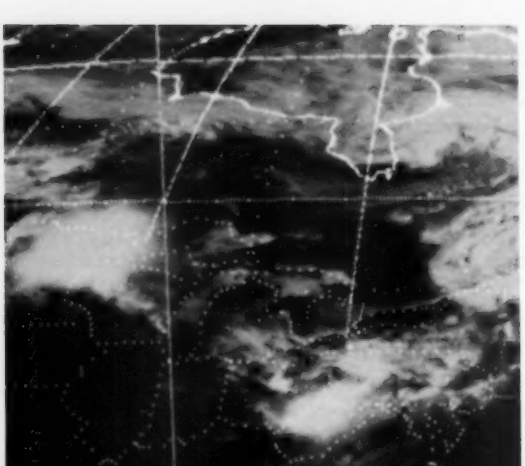


Figure 36.--This satellite image shows the fog over the Upper Lakes on Independence Day.

On the 4th and 5th severe thunderstorms hit Michigan and Ohio. A waterspout occurred over Saginaw Bay near Au Gres. Thunderstorms with winds up to 60 mi/h moved off Lake Erie into northern central Ohio. In one case, 1-1/4 in hail was reported. There were no reports from ships. To the north at Sault Ste. Marie the Soo Locks were closed due to dense fog with visibility less than 1/4 mi. It is strange that July, one of the more unstable air mass months with many thunderstorms, was also the month with the most low-visibility reports, which generally require stable air conditions (fig. 36).

On the 18th severe thunderstorms again moved off Lake Erie into the Lorain-Sandusky area. The Coast Guard reported several waterspouts on the Lake. High winds overturned small boats and caused considerable shore damage.

A weak frontal wave traveled eastward over the Great Lakes on the 25th. A HIGH was centered near Lake Winnipeg. The 1800 observation of the ERNEST T. WEIR and JOHN SHERWIN on Lake Huron indicated 32- and 33-kn winds from the northwest. The J. BURTON AYERS on Lake Erie at 0000 on the 26th measured 31-kn northerly winds. The clockwise circulation of the HIGH brought in cold air from the Hudson Bay. Farther north new cold-temperature records were set for many stations in Michigan, Ohio, and Wisconsin. The lowest was 42°F in Lansing, Mich.

AUGUST

There were only four synoptic wind reports over 30 kn plus one special observation for the entire month. On the 12th a multicentered LOW was moving eastward over Hudson Bay with the southernmost center near James Bay. High pressure was centered over Kansas. At 0000 on the 12th the CLIFFS VICTORY was on the eastern end of Lake Superior with 32-kn winds from the west. At 1800 the ARTHUR M. ANDERSON had southerly 34-kn winds on central Lake Michigan.

A low center traveled northeastward across the Lakes on the 16th and 17th. High pressure was over Iowa. At 0600 on the 18th the J. BURTON AYERS and MIDDLETON were on Lake Huron. They measured northwesterly 33- and 32-kn winds. None of the seas were over 8 ft.

On the 27th at 0630 the JOHN DYKSTRA was 9 mi northeast of Eagle Harbor on Lake Superior when she reported a thunderstorm with 34-kn south-southwesterly winds. The report indicated "3-ft waves and building."

SEPTEMBER

There were two special observations to start off the month on the 1st. Both were on Lake Superior by the ERNEST T. WEIR and JOHN DYKSTRA. The WEIR was 3 mi north of Eagle Harbor (seemingly a favorite spot for severe thunderstorms) at 0515. The winds were west-southwesterly at 40 kn with gusts to 50 kn. The seas were 6 ft and building. The DYKSTRA was 13 mi east of Manitou Island at 0800 with winds of 38 kn from 300° with gusts to 42 kn. The seas were 7 ft and building.

A storm center formed over North Dakota on the 8th. The Soo Locks were again closed due to fog. It moved northeastward and at 1800 on the 9th was at 50°N, 90°W, about 90 mi north of Thunder Bay at 986 mb. The CHARLES M. BEEGHLY was south of Isle Royale and encountered 56-kn winds from the southwest (fig. 37). No severe weather was reported by land stations around the lake; they were reporting rain and rain showers. The seas were 15 ft. This was the highest wind measured on the Lakes this calendar year and submitted to the National Climatic Center. The J. BURTON AYERS had northwesterly winds of 32 kn on Lake Huron 24 hr later as the storm continued northwestward.

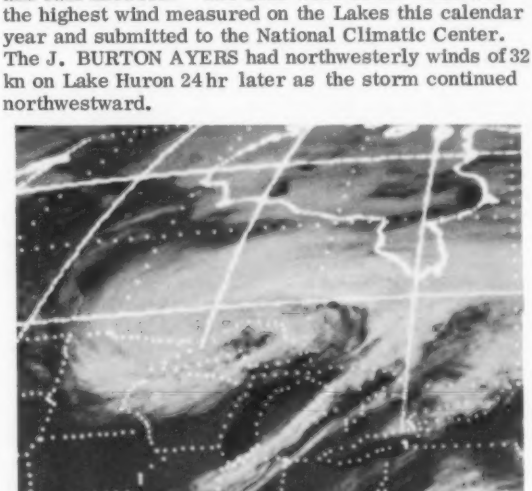


Figure 37.--The cyclone which produced the highest wind of the year on the Lakes is recorded in this image for September 9.

This summer storm produced 9 of the 13 observations of winds over 30 kn for the month. It was a slow-moving storm, especially as it moved west of Lake Superior. It had its origin over western Nebraska on the 23d. At 1200 on the 24th it was centered at 992 mb near the North and South Dakota-Minnesota border. The G.M. HUMPHREY was west of the Straits of Mackinac with east-southeasterly winds of 44 kn. Six hours later on Lake Huron they were 37 kn with 10-ft seas. Winds up to 70 mi/h were reported by the Michigan State Police on the Mackinac Bridge. At 0000 on the 25th they had increased to 42 kn with 13-ft seas. On the 27th the ship was on western Lake Erie with westerly 32-kn gales. Back to the 24th at 1800 the JOHN DYKSTRA was following the HUMPHREY up Lake Michigan with 42-kn winds. Forty-eight hours later she too was on Lake Erie with westerly 31-kn gales. The storm had tracked slowly northeastward and crossed the Canadian border near Lake of the Woods at midday on the 25th. At 1200 on the 26th it was over Lake Nipigon, and a second center had formed near Detroit with thunderstorms along the trough connecting the LOWs. On the 27th the storm picked up speed and left the area.

OCTOBER

On the 1st day a LOW was assembling over western Kansas. By 1200 a second center had formed over the central Indiana-Ohio border to make an elongated oval storm. On the 1st the ERNEST R. BREECH was sailing southward on Lake Huron with three observations of 33- to 36-kn east-northeasterly winds. At 1200 and 1800 the JOHN DYKSTRA was sailing northward on southern Lake Michigan measuring 40- and 38-kn easterly winds. The second LOW quickly became the primary storm and raced eastward.

A LOW developed near Great Salt Lake on the 6th. By 1200 on the 8th the 995-mb center was over central Wisconsin. The G.M. HUMPHREY was near Pelee Island measuring 41-kn southeasterly winds, and the JOHN DYKSTRA was off Bayfield with 48-kn winds from 140° and 13-ft seas. At 1800 the ELTON HOYT II on Lake Superior had 32-kn easterlies. Gusts to 45 kn were forecast for Lake Ontario. There were no winds over 30 kn as the storm center crossed the Soo Locks on the 9th to continue to the Labrador Sea.

This storm formed over Wisconsin late on the 10th and followed in the tracks of the previous one. The reported winds were not as strong, generally in the lower 30-kn category. The first report was by the G.M. HUMPHREY at 0600 on Lake Superior. The last report was by the J. BURTON AYERS on Lake Erie at 12/0600. The storm picked up speed after crossing the Lakes and was near Ungava Bay on the 13th. Lake shore warnings for beach erosion were issued for Lake Michigan. The remainder of the month was quiet with fog again hampering ships at the Soo Locks on the 20th and 27th.

NOVEMBER

This can be one of the roughest weather months on the Lakes, but the record does not indicate it this year. The first significant storm formed late on the 8th over southwestern Missouri and moved due north over the western tip of Lake Superior. The first gale-force wind was reported on Lake Superior at 1800 by the SAMUEL MATHER off the Apostle Islands. She continued to report gale- to strong gale-force winds for the next 30 hr as she sailed eastward. The highest wind was 42 kn at 1200 on the 11th south of Isle Royale with -5°C temperature. During this period the storm was moving northeastward at about 990-mb pressure. This day has been marked by at least two major storms and disasters--the blizzard of 1940 and the sinking of the EDMUND FITZGERALD in 1975. By the 12th the pressure had dropped to 980 mb over northern Quebec. The J. BURTON AYERS was on Lake Erie with 30- to 35-kn winds. On the 13th the storm was over the Davis Strait.

A LOW developed near Chicago on a weak front on the 25th. By 0000 on the 26th it was 997 mb over the Welland Canal. Gale warnings were posted for Lake Ontario. High pressure was pushing southeastward from the high plains. The CHAMPLAIN was sailing northward on Lake Huron and at 0600 was blasted by 48-kn northwesterlies. At the same time the J.A.W. IGLEHART was at Port Huron with 45-kn winds. By the 27th she was underway heading northward into 13-ft seas. The winds had dropped to 40 kn and then to 35 kn.

DECEMBER

The number of observations increased on all the Lakes this month over October and November except Lake Erie for November.

Late on the last day of November a LOW formed near Memphis, Tenn., and raced northward. By 1200 on December 1 it was 984 mb over central Michigan (fig. 38). The CHARLES M. WHITE was east of Port

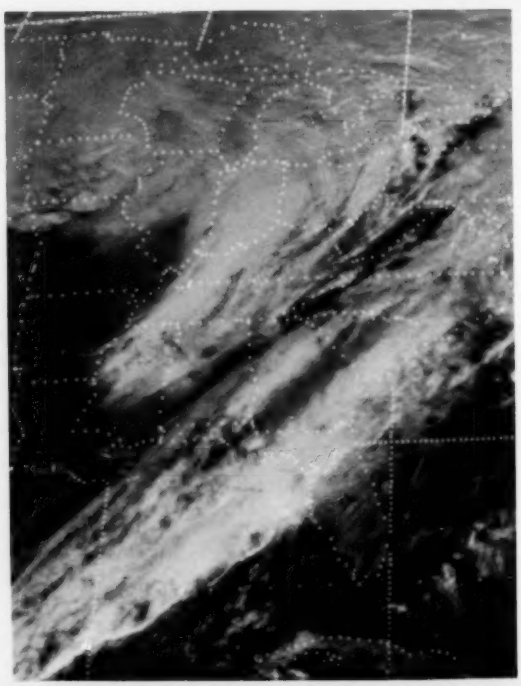


Figure 38.--The CHARLES M. WHITE and the 16.5-ft waves on Lake Huron are hidden under the clouds.

Austin on Lake Huron with 40-kn southwesterly winds and the highest waves of the year--16.5 ft. By 1200 on the 2d the 970-mb storm was over James Bay, but still having a large affect on the Lakes. Flood and erosion warnings were out for Lake Erie due to the high winds and waves. The SAMUEL MATHER was now on Lake Erie with 44-kn winds from the southwest and 13-ft seas. Six hours later, the J.A.W. IGLEHART had 40-kn southwesterly winds and 13-ft seas on her port quarter on Lake Huron. On the 3d the storm had moved far enough north into Canada that the winds over the Lakes were below gale force.

This storm had a head start on the Lakes by forming near Gary, Ind., late on the 8th. It was a 995-mb storm by 1200 on the 9th over Georgian Bay. The ERNEST R. BREECH was on Lake Huron at 0000 on the 9th as the center moved over the Lake and measured 42-kn southeasterly winds and 12-ft seas. At 0600 the J.A.W. IGLEHART had easterly winds at the mouth of the St. Marys River. By the 10th the winds had dropped below 30 kn.

There was more warning on the approach of this storm as it developed over western Kansas on the 16th. On the 17th at 1200 the 986-mb center was over Iowa. The winds on Lakes Huron and Superior were minimum gale force. By 1800 the G.M. HUMPHREY north of Rock of Ages was buffeted by east-southeasterly 48-kn winds. The LEON FALK JR had minimum gales on Lake Huron. A large 1046-mb HIGH was moving southeasterly across northern Hudson Bay and blocking the northward progress of the LOW. It was weakening gradually, but the intense HIGH kept the pressure gradient tight. On the 18th the CLIFFS VICTORY found 38-kn winds and 15-ft seas with squalls on Lake Huron. The LOW was being shoved northwestward by the HIGH and had deteriorated to mostly an inverted trough on the 19th with the more intense gradient of the HIGH northeast of the Lakes.

ACKNOWLEDGMENTS

An expression of appreciation is extended to the masters and mates aboard the Great Lakes cooperating vessels for their valuable observations and contributions to the National Weather Service observing program. Much useful information and photographs were obtained for this article through the courtesy of Albert G. Ballert and the Great Lakes Newsletter of the Great Lakes Commission. National Weather Service meteorological and ice data were provided by Daron E. Boyce of the National Weather Service Forecast Office in Cleveland, Ohio.

Of primary importance were the listings of wind, wave, visibility, ice, and special observations prepared by John Snelling of the Applied Climatology Branch of the National Climatic Center on which most of the specific weather information in this article is based.

Hints to the Observer

HURRICANE REPORTING

Dear Captain:

I'd like to remind you that the hurricane season (June through November) is near. In order for us to provide adequate warnings, it is essential that we receive as much information as possible from ships encountering evidence of hurricanes.

To assist our forecasters in determining storm location, intensity, and movement, we would like you to:

1. Make and transmit reports at least at 3-hr intervals when within 300 mi of a tropical storm or hurricane.

2. Include in "Remarks" the lowest pressure and/or the highest wind encountered if, since the last synoptic report:

   a. The pressure was more than 5 mb lower, and/or

   b. The wind was more than 15 kn higher than the present value(s).

   Also, include the time of occurrence.

   Example: 0800Z LOWEST PRESSURE 970MB 0730Z HIGHEST WIND 85KN.

I've enclosed copies of "General Instructions for Radio Reporting of Weather Observations" for your use.

The National Weather Service appreciates the time and effort you and your officers give to provide reports of weather conditions at sea. Your reports are extremely important considering the vast ocean spaces and the relatively few ships that report weather.

Sincerely,

George P. Cressman

George P. Cressman
Director, National Weather Service

GENERAL INSTRUCTIONS FOR RADIO REPORTING OF WEATHER OBSERVATIONS

Standard Synoptic Observation Times -- The regular weather-reporting hours are 0000, 0600, 1200, and 1800 GMT. Occasionally, watch schedules or priority of other duties make it impractical to make and transmit surface observations at standard synoptic times. To ensure message transmission, observations may be made in advance of the weather-reporting hours. In these cases, the actual time of observation should be included in the report.

Coded Weather Messages--All messages to be transmitted by radio should be transcribed from the ship's weather log to NOAA Form 72-4, "Weather Report for Immediate Radio Transmission," in the ship synoptic code FM21V or FM23V and given to the Radio Officer.

Transmission of Radio Messages--Weather messages should be transmitted as soon as possible to the most convenient radio station in accordance with instructions contained in United States and Foreign Coastal Radio Stations Accepting Ships' Weather Observation Messages.

Weather Message Addresses for Transmission to U.S. Radio Stations--Use "OBS METEO WASHDC" when in the:

1. Western North Atlantic, including the Gulf of Mexico and Caribbean Sea, north of 3°N latitude, and west of 35°W longitude (WMO Region IV-A).
2. Eastern North Pacific (north of the Equator), east of the 180th meridian (WMO Region IV-A).
3. Eastern South Pacific (south of the Equator), from the South American coast to 120°W longitude (WMO Region III-B).

Use "OBS METEO GUAM" when in the western North Pacific between 5° and 25°N latitude, and from 135°E to the 180th meridian (WMO GUAM ZONE).

Observations During Storm Conditions--Whenever TROPICAL STORM, TYPHOON, or HURRICANE conditions are encountered anywhere, "SAFETY OF LIFE AT SEA CONVENTION," Chapter V, requires all ships to take a special observation and transmit the report to the closest national meteorological service via the most convenient radio station. In addition to this requirement, it is highly desirable that weather reports be transmitted hourly if possible, but, in any case, not less frequently than every 3 hr.

Special Requests for Observations--During storm situations, the U. S. National Weather Service may request ships located in areas of suspected storm development to take special observations at more frequent intervals than the routine 6-hr synoptic observation times. If your ship happens to be in such an area, your report will be helpful even though conditions may not appear bad enough to warrant a special observation. To speed delivery of messages from storm areas and to identify them as such, the word STORM should appear immediately following the radio address. These messages should be addressed to the requesting forecast office. For example, "OBS METEO NEW YORK STORM 99305 70750," etc., would be used if the New York Forecast Office requested the observation.

Observations in Coastal Waters--Since radio weather reports are always needed from ships in coastal waters, observations should continue to be taken as close to shore as ship routine permits.

Tips to the Radio Officer

Thomas H. Reppert
National Weather Service, NOAA
Silver Spring, Md.

CORRECTIONS TO WORLDWIDE MARINE WEATHER BROADCASTS (July 1977 Edition)

All times are GMT, and frequencies are kHz unless otherwise indicated.

Page 8 1-0230
Mobile, Alabama (WLO)
Delete time 1700

Page 19 1-0930
Honolulu, Hawaii (NMO)

0500, 2000	440	W^2F^2
H+18 or H+48	440	W^2
0530	8650, 12889.5	W^3F^3
2030	8650, 12889.5, 16909.7	W^3F^3

Page 34 2-0020
Ocean Gate, N.J. (WOO)

0100, 1300, 1900	4385.3, 8740.6, 13107.0, 17245.3, 22596.0
0200, 1400, 2000	4403.9, 8762.3, 13131.8, 17310.4, 22623.9

Page 36 2-0250
Shinnecock, N.Y. (NMY-41)

0020, 1220	2670	W, F
*0920, 1220, 1520, 1820, 2120, 0020	2670	W, F

*Boating season only May 15 to October 15

Page 37 2-0320
Fort Macon, N.C. (NMN-37)

0103, 1240	2670	W, F

2-0370
Miami, Florida (WOM)

1230	4363.6, 8722.0, 13116.3, 17232.9
1330	4391.5, 8731.3, 13122.5, 17257.7
2230	4407.0, 8746.8, 13125.6, 17260.8
2330	4425.6, 8793.3, 13144.2, 17263.9

Page 38 2-0420
Mobile, Alabama (WLO)

Area:
(a) Gulf of Mexico
(b) Caribbean Sea
(c) Southwest North Atlantic
(d) Coastal waters, Apalachicola to Biloxi

0500, 1100[2] 1700, 2300	2572.0, 4397.7	W, F
1330, 1730[3] 2330	8790.2, 13178.3, 17356.3	W, F
1300, 1700[4] 2300	161.9 MHz, 162.0 MHz	

[2] For area a
[2] For area b and c
[3] For area d

Page 46 2-1170
San Francisco, Calif. (KMI)

0000, 0600, 1500	4357.4, 8728.2, 8784.0, 13100.8 13187.6, 17236.0

Page 47 2-1210
Cold Bay, Alaska (KCI95)

0500, 1700	2512
0800, 2200	4125

2-1231
Kodiak, Alaska (WBH-29)

0400, 1800	4125

2-1240
Yakutat, Alaska (KGD91)

0900, 2100	2382
0330, 1600	4125

2-1260
Juneau, Alaska (KCI97)

Delete station.

Page 48 2-1290
Annette, Alaska (KGD-58)

1000, 1500	4125

Page 50 2-1530
Honolulu, Hawaii (NMO); Honolulu, Hawaii (KHP)

Amend area (a) Coastal waters out 100 miles, etc.

Page 79

Roger City, MI	WLC	6:17 and 12:17 a.m. and p.m. EST
Tawas City, MI (Slave Station)	WLC	" "
Charlevoix, MI (Slave Station)	WLC	" "

ACKNOWLEDGMENTS

Thanks to Restituto G. Dela Torre, MS GUAYAQUIL, and Richard White, SS SOLON TURMAN, for information relative to the marine weather program.

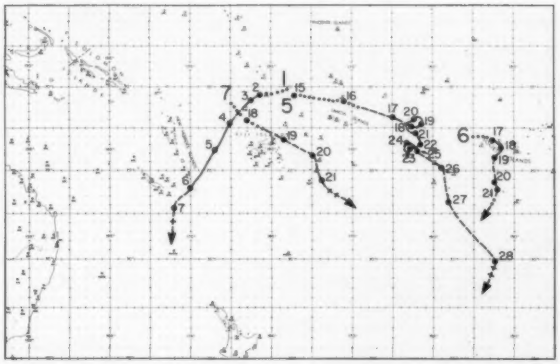
Hurricane Alley

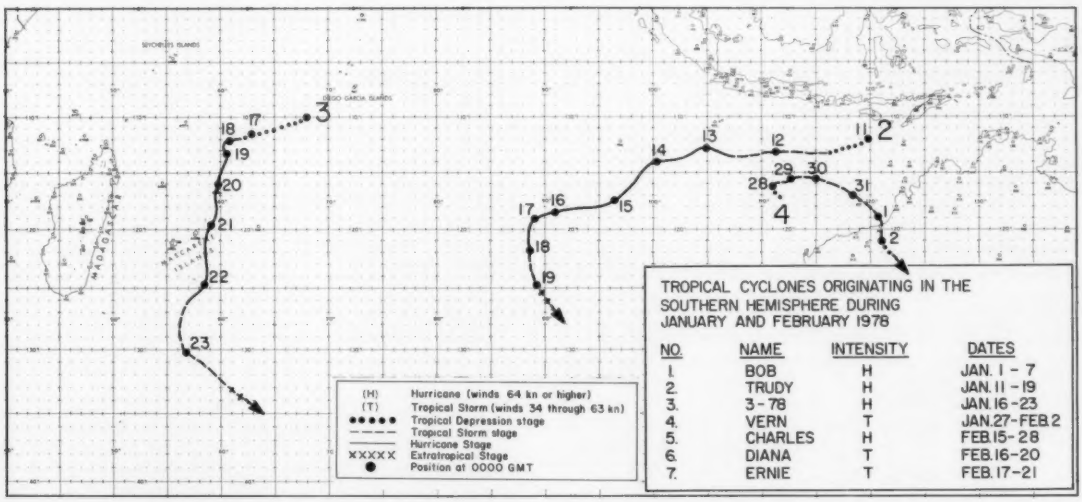
Dick DeAngelis
Environmental Data Service, NOAA
Washington, D. C.

These summaries and tracks (fig. 39) are based on tropical cyclone information provided by the National Environmental Satellite Service. The warnings issued by the Joint Typhoon Warning Center are also used.

SOUTH PACIFIC
JANUARY AND FEBRUARY 1978

Around Australia and in the South Pacific six tropical cyclones (tropical storms or hurricanes) developed during the first 2 mo of the year. Three developed in each month, and three reached hurricane intensity. Hurricane Bob kicked off the New Year north of the Fiji Islands. He reached hurricane strength on the 3d and peaked on the 5th, when maximum sustained winds were estimated at 90 kn with gusts to 105 kn (fig. 40).




SEYCHELLES ISLANDS
DIEGO GARCIA ISLANDS
MADAGASCAR
MASCARENE ISLANDS
(H) Hurricane (winds 64 kn or higher)
(T) Tropical Storm (winds 34 through 63 kn)
Tropical Depression stage
Tropical Storm stage
Hurricane Stage
Extratropical Stage
Position at 0000 GMT
TROPICAL CYCLONES ORIGINATING IN THE SOUTHERN HEMISPHERE DURING JANUARY AND FEBRUARY 1978

NO.	NAME	INTENSITY	DATES
1.	BOB	H	JAN. 1 - 7
2.	TRUDY	H	JAN. 11 - 19
3.	3 - 78	H	JAN. 16 - 23
4.	VERN	T	JAN. 27 - FEB. 2
5.	CHARLES	H	FEB. 15 - 28
6.	DIANA	T	FEB. 16 - 20
7.	ERNIE	T	FEB. 17 - 21

Figure 39.--Tracks of tropical cyclones in the Southern Hemisphere during January and February 1978.

Figure 40.--New Caledonia lies hidden beneath Bob's hurricane circulation late on the 5th.

At this time Bob was just south of the New Hebrides Islands. He weakened rapidly as he skirted southern New Caledonia. A few days later Trudy was detected off Sumba Island (fig. 41). By the 13th she was generating 65-kn winds around her center. She peaked at about 80 kn just before recurving on the 16th. Within the next few days she began to weaken and turn extratropical. Tropical storm Vern came to life off the northwest coast of Australia on the 27th. He headed southeastward and ran aground near Port Headland on February 1 (fig. 42). Maximum winds were estimated at 55 kn shortly before landfall.

Charles, Diana, and Ernie, an unlikely trio, formed within 2 days of each other. Charles, the only hurricane, outlived the other two by a week. His path was similar to that of a drunken sailor and included a cou-

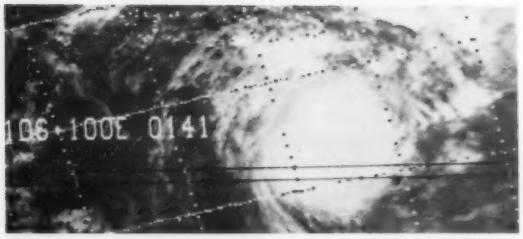


Figure 41.--Trudy is caught developing rapidly between Australia and southern Indonesia early on the 12th.

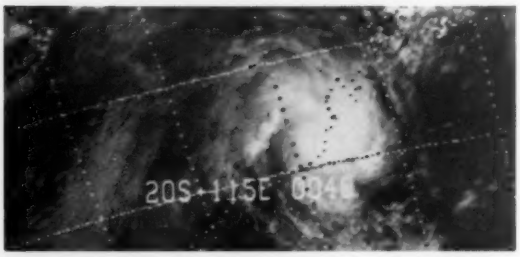


Figure 42.--Vern bangs the northwest coast of Australia early on the 1st.

ple of loops. He attained hurricane force on the 23d (fig. 43) and maintained it for 2 days. Maximum winds were estimated at 75 kn. Charles managed to stay clear of the major islands. Diana developed while meandering through the Society Islands on her way south. Her winds attained speeds of 50 kn from the 17th through the 19th. Meanwhile, Ernie was making his way toward the Fiji Islands, also carrying 50-kn winds. He brushed the island of Vanua Levu on the 18th. Continuing on a southeasterly track, Ernie became extratropical by the 21st.

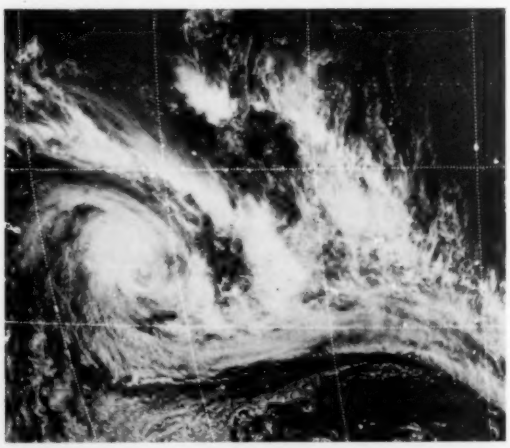


Figure 43.--Hurricane Charles flexes for the camera late on the 23d.

SOUTH INDIAN OCEAN
JANUARY AND FEBRUARY 1978

While several depressions roamed these waters during the first 2 mo, only one seemed to intensify to tropical storm strength, and it reached hurricane strength. The storm formed on February 16 southwest of Diego Garcia. By the 19th winds had reached hurricane force, and they were estimated at 100 kn the following day as it moved across St. Brandon. The storm was still intense as it passed 60 mi east of Mauritius on the 21st, but it began to weaken later in the day. By the 22d, it fell to tropical storm strength and the following day started to turn extratropical.

TROPICAL CYCLONE NAMES FOR 1978

An historical event in hurricane equality will occur sometime in June or July when Bud is christened in the eastern North Pacific. After a quarter of a century of female domination, the Northern Hemisphere tropics are climbing out of the dark ages. Free at last! Free at last! No longer will we be constantly besieged with the Camilles, Betsys, and Hazels. Soon there will be hope for the Andys, Bobs, and Daniels.

This desegregation will not be a radical changeover however. To lessen the shock, this system of using alternate male and female names will begin in the eastern Pacific this season and spread to the North Atlantic and western North Pacific next year. While this move is considered revolutionary in meteorological circles, it actually was started a few years ago by our tropical brothers in the Southern Hemisphere. Why just this past February the South Pacific spawned tropical storm Ernie. We've come a long way, Baby.

The following is the list of names for the 1978 season. A new list is started each year in the eastern Pacific and North Atlantic, while the western Pacific simply continues the alphabet.

Atlantic	Eastern Pacific	Western Pacific	
Amelia	Aletta	Olive	Hester
Bess	Bud	Polly	Irma
Cora	Carlotta	Rose	Judy
Debra	Daniel	Shirley	Kit
Ella	Emilia	Trix	Lola
Flossie	Fico	Virginia	Mamie
Greta	Gilma	Wendy	Nina
Hope	Hector	Agnes	Ora
Irma	Iva	Bess	Phyllis
Juliet	John	Carmen	Rita
Kendra	Kristy	Della	Susan
Louise	Lane	Elaine	Tess
Martha	Miriam	Faye	Viola
Noreen	Norman	Gloria	Winnie
Ora	Olivia		
Paula	Paul		
Rosalie	Rosa		
Susan	Sergio		
Tanya	Tara		
Vanessa	Vicente		
Wanda	Willa		

On the Editor's Desk

NEW PMO FOR NEW YORK

A new Port Meteorological Officer has been assigned to the New York National Weather Service Forecast Office. He is Charles Schlott (fig 44). Charles served in the United States Navy from 1956 to 1960. He was aboard the USS SARATOGA and in hurricane reconnaissance for 2 yr. From 1960 until 1976 he worked in private meteorology with the National Weather Corporation. He joined the National Weather Service in 1977 as a radar specialist until his assignment as the Port Meteorological Officer.

Figure 44.--Many of the ships' officers have probably already met Charles Schlott on his visits around the port of New York.

UNIVERSITY OF WASHINGTON AWARDED CONTRACT FOR ARCTIC RESEARCH

The University of Washington has been awarded more than half a million dollars in supplemental contracts during the past month by NOAA to continue studies on Arctic Ocean nearshore ice behavior, currents, and minute marine life in the Gulf of Alaska.

The contracts are part of a major environmental study conducted by the Outer Continental Shelf Environmental Assessment Program (OCSEAP) of NOAA's Environmental Research Laboratories for the Bureau of Land Management of the Department of Interior. The studies seek to determine the probable ecological impacts of oil exploration and development activities on Alaska's outer continental shelf.

University scientists will study ice floe behavior on the continental shelf of the Beaufort and Chukchi Seas in the Arctic Ocean. Satellite-tracked buoys will record ice motion and behavior in a region where ice floes have traveled as much as 100 km (62 mi) per day.

Under a separate task order, supplemental funds have been authorized for a Department of Oceanography scientist to further his studies of microscopic fish and shellfish or "Meroplankton" inhabiting the Lower Cook Inlet in the Gulf of Alaska.

Funds were also awarded to the Department of Oceanography to continue studies of oceanic currents in Bristol Bay east of the Pribilof Islands and to gather long-term moored current meter records in the Norton Sound-Chukchi Sea region including the Bering Strait.

STANDARDS TO PROTECT GREAT LAKES VESSELS AGAINST SINKING

The U.S. Coast Guard is considering development of standards for watertight subdivision of cargo holds on Great Lakes bulk dry cargo vessels to minimize the danger of sinking.

The minimum stability standards should help the vessels to survive flooding caused by damage to the hull or to watertight closures (hatch covers).

A review of the worst Great Lakes accidents over the past 20 yr indicates that adopting such standards would make ships and crews safer. It was noted that three cargo vessels that sank with the greatest loss of life--the CARL BRADLEY, DANIEL T. MORRELL, and the EDMUND FITZGERALD--went down rapidly after structural failures led to massive flooding and loss of buoyancy. The EDMUND FITZGERALD sank on November 10, 1975, with 29 people lost. Flooding of the cargo hold through ineffective hatch closures during a severe storm was held to be the cause.

THE NATION'S IRREPLACEABLE WEATHER DATA

The Nation's weather records have been collected in ever-increasing numbers for almost 100 yr. The collection is worldwide and contains observations made at locations on land and sea and in the atmosphere. It consists of about 160 million pages of original records and 99,000 reels of magnetic tape containing weather data. The records are archived at the National Climatic Center (NCC) in Asheville, N.C., and are made available to users around the world through publication of selected data in serial data bulletins and response to user requests. A micrographics program is being implemented that will reduce the storage space drastically, make the invaluable records safer from possible damage or destruction, and provide for their rapid retrieval through a highly responsive, computerized data bank system.

The National Climatic Center is the official repository for the meteorological records, selected environmental data, and climatological publications and tabulations produced by its computer system. The records come from various Federal agencies, including the National Weather Service, the Federal Aviation Administration, Weather Services of the U.S. military, volunteer weather observers, foreign countries, Merchant Marine vessels, and research conducted in collaboration with foreign nations. The official weather maps prepared by the National Weather Service are included. The volume of the records is nearly 100,000 ft^3, occupying about 50,000 ft^2 of floor space and 25 mi of steel shelves. The records are expanding at a rate of about 2,000 ft^3 (3.5 million sheets) per year.

Users are private citizens, industry, universities, Federal agencies, courts of law, and foreign countries to mention a few. Some important uses of the data are meteorological, agricultural (increasing food production), medical and wind energy research, assessment of the effect of climate on human activities, engineering design, air pollution control, transportation systems design, lawsuits, distribution of consumer products, and reduction of the human and physical damage by severe local storms and hurricanes. The original weather records are vulnerable to damage and destruction from a number of causes and could not be reconstructed if lost. Safeguards to preserve this valuable national resource are essential.

A microform-based system will make safe storage possible and at the same time provide flexibility in selecting and organizing materials to user specifications. The primary micrographics data base selected by NCC is microfiche. This technique permits the placing of large quantities of original records and printed materials on small film frames which do not deteriorate readily and are easily stored in comparatively small volume. About 60 million of the 160 million records on hand are now being filmed without interruption 24 hr a day, 7 days a week. Key information for selecting and retrieving needed data on these microfiche is being entered into NCC's computer data base. This computer-based inventory system will greatly facilitate the selection of a wide variety of information from the microfiche data base for preparation to user specifications. The increased efficiency also reduces service costs.

Quality assurance personnel see that the integrity of technical information on records is permanently preserved on the microforms, that they are adequate replacements for the original records, and that they serve the purposes for which the original records were created. All records are on archival quality film that meets the standards of the American National Standards Institute.

Two second-generation silver negative copies of the original rolls are made and cut into 6 in by 4 in microfiche. The original rolls are left intact and wound on cores that are chemically inert. They are packed in acid-free boxes and stored in climate-controlled space at a Federal Archives and Records Center, far distant from NCC. One storage box (about 1 ft^3) contains about 600,000 records. The present collection of NCC consists of 150,000 master microfiche. To film the 60 million records, yielding about 1 million additional microfiche, will take about 5 yr with adequate resources.

The original records will not be destroyed. After they are properly filmed and a copy of the film is stored offsite, they will be shipped to various State archives to be used as unofficial collections in serving intrastate needs.

NCC users are worldwide. In a recent year about 1 million paper copies of climatological data were provided to users and a million issues of current climatological publications were distributed. About 250,000 out-of-print back issues were reproduced, and around 40,000 microfiche and 10,000 35-mm and/or 16-mm rolls of film were furnished as users became more willing to accept microforms instead of paper copies.

As the program to automate indexes of the microfiche proceeds, the microfiche themselves are being stored in power files to further improve records management procedures and expedite the retrieval of needed microfiche. Each power file has a capacity of 110,000 microfiche, and eight such files will be required to store the microfiche produced from the 60 million records ultimately to be filmed. These files will be an integral part of a Microfiche Service Center which will include video-display terminals for querying NCC's computer data base to determine quickly the availability and location in the power files of needed data on microfiche. The Microfiche Service Center, which will occupy about 2,000 ft^2 of floor space, will also include other essential accessories such as film reader-printers, devices for producing microfiche copies from the master microfiche, and high-speed, high-volume printers to provide hard-copy prints from microfiche. When fully implemented, the Center will be able to fill requests for meteorological and climatological data and information in one-tenth the time now required and at a much reduced cost both to the user and the taxpayers.

STATE UNIVERSITY SYSTEM OF FLORIDA STUDIES EROSION

How to predict the magnitude of beach and dune erosion caused by storms is the goal of a project to be launched this year by scientists of the State University System of Florida under a Sea Grant from NOAA.

The research, given added importance because of heavy erosion caused by numerous storms this winter, will be among 21 projects and activities programmed this year under the grant. Non-Federal support has been pledged in matching funds.

The main factors involved in the highly complex nature of erosion processes are high-water levels, increased wave activities, and the material composition of the beaches and dunes. These will be studied in field tests, after which laboratory experiments will evaluate storm-duration effect, the characteristics of nearshore and beach-dune profiles after storms, the effect of repeated storms, and actual measurements compared to those deduced from analysis.

The State University System includes Florida Atlantic University, Florida Institute of Technology, Florida State University, Nova University, University of Florida, University of South Florida, and the University of West Florida.

UNITS WIN NATIONAL AWARD

The Department of Commerce Public Service Award was presented recently to the 53d Weather Reconnaissance Squadron (WRS), 920th Weather Reconnaissance Group (WRG), and Detachment 5, Headquarters Air Weather Service, for the units' flawless 2-yr record of providing critical weather data to the National Weather Service hurricane forecasters.

This award, considered the nation's highest service award, was presented to these units in recognition of their services to the public safety and welfare. In a citation accompanying this award, particular mention was made of the accurate and timely data these units provide during storm missions. An excerpt read, "The vital data your staff provides, enhances the forecaster's ability to determine hurricane position and intensity, prepare accurate forecasts and issue appropriate hurricane advisories to civilian, military and marine interests. This information saves an untold

number of lives each year and averts significant property losses."

Flying nearly 800 hr in support of the Department of Commerce (70 flights into the very centers of tropical storms and hurricanes) members of these units flew six named storms last year in the Atlantic, Gulf, and Caribbean, including hurricanes Anita, Babe, Clara, Dorothy, and Evelyn and tropical storm Freida. Data were also collected on hurricane Doreen.

There were nine named storms flown in 1976, with 931 hr logged. Not a single fix requirement was missed during either of these 2 yr.

Already this year, Hurricane Hunter crews from the 53WRS and Detachment 5, and a Storm Tracker crew from the 920WRG have flown investigative missions into a tropical cyclone northeast of Puerto Rico. Tropical storm development is unusual this time of year, and with on-the-spot weather data in hand, the hurricane forecasters were able to correctly predict the cyclone's dissipation.

The award was a joint tribute by the Department of Commerce and the National Weather Service of NOAA.

FIRST SHIPS OF 1978 ENTER SEAWAY

The first commercial vessels of the 1978 navigation season have entered the Montreal-Lake Ontario (International) Section of the St. Lawrence Seaway, inaugurating what could be a crucial year for the Seaway System.

Official traffic estimates call for levels approaching the record volume of cargo that moved through both the International Section and the Welland Canal in 1977. In the Montreal-Lake Ontario Section, that figure was 63.3 million short tons, while in the Welland Canal the total reached 71.7 million tons.

The 31,135-ton French-flag vessel HERMINE was the first commercial ship to enter the Montreal-Lake Ontario Section this year, according to the U.S. Saint Lawrence Seaway Development Corporation. The ship, moving in ballast and scheduled to make its initial call at Toledo, cleared the Seaway System's outermost lock at St. Lambert Avenue on April 3. Liberian- and Greek-flag freighters also cleared St. Lambert on April 3, and an upbound Yugoslav-flag vessel transited the lock the next morning. Also, another ocean vessel and five Lakes vessels at Montreal Harbor were waiting to move upbound through the Seaway.

The first downbound ship through the International Section was the J.N. MCWATTERS, a 730 ft long bulk-carrier hauling grain to Montreal. It was followed by four other vessels, at least one of them carrying corn to Montreal, another hauling corn to Port Cartier, and a third transporting grain to Port Cartier.

Ice ranging between 30 and 36 in in depth remained in the intermediate portion of the International Section, but a United States and Canadian icebreaker were working to maintain a track in the area.

The Welland Canal opened on March 28.

WINTER MAY HAVE HIT NEW LOW IN EAST

Average temperatures east of the Rocky Mountains during this past December through February appear to have hit a new low, according to Robert G. Quayle of EDS's National Climatic Center. While January of 1977 still stands as the coldest single month since formal weather record-keeping began in the late 1800's; for the winter as a whole, this winter's temperatures probably were worse than last.

Further, the combined average for two cold winters back-to-back shows the winters of 1977 and 1978 almost certainly setting a new low, vying with the winters of 1904 and 1905 for the record.

These preliminary conclusions are based upon a sampling of reports collected from several dozen National Weather Service stations scattered around the country. EDS's National Climatic Center in Asheville, N.C., will have final results in several months, after data from some 10,000 sources have been received and processed.

Despite some similarities, much of this winter's weather resulted from somewhat different circumstances than last year, as evidenced by the record drought in the far West last winter and the record floods this season.

Both winters exhibited high pressure in the West and low pressure in the East combining to pump cold arctic air deep into the heart of the United States, but this year's high-pressure area was farther north and east over Canada, leaving California open and exposed to Pacific storms. The jet streams were more intense, farther south, and less convoluted this year. Instead of a steady cold flow, like last year, this year's storms alternated at intervals of about 5 days, bringing snowy bursts of cold air with them every time. Both winters were similar in that the far West was warmer than normal.

Around the country, 1978 established new record cold-winter average temperatures at such widely scattered places as Galveston, Tex.; St. Louis, Mo.; Cincinnati, Ohio; Nashville, Tenn.; and Concordia, Kans.

SEA ENERGY BUOY OPERATING IN GULF

A 100-ton buoy named OTEC - 2 has started to collect data in the Gulf of Mexico to provide important information on the mechanics of extracting energy from the sea.

The 40-ft diameter discus buoy, a product of NOAA, has been equipped to test the effect of seawater on Ocean Thermal Energy Conversion (OTEC) power plants. Such plants, currently in the experimental stage, generate electricity by using the temperature differential between the warm surface layers of the ocean and the colder waters below.

Under an interagency agreement with the Department of Energy, NOAA has moored the huge, unmanned buoy approximately 180 mi west of Tampa, Fla. It will remain on station for 3- to 6-mo periods and measure the effects of biological fouling, corrosion, and scaling on heat transfer surfaces of the heat exchangers to be used in OTEC power plants.

The NOAA Data Buoy Office has equipped OTEC-2 with a hydraulic flow system, which pumps seawater from a depth of 75 ft through tubes of aluminum and titanium into the heat transfer monitor assemblies. These metals are being evaluated for use in full-scale OTEC plants, both because they are relatively corrosion free and because they contain the heat within the pipe.

A water quality indicator system is included to measure dissolved oxygen, acidity, turbidity, and conductivity of seawater. The buoy also contains a standard set of meteorological sensors for collecting weather data at the OTEC-2 site. The experimental

data will be analyzed by several government agencies and universities to determine the nature of the fouling in the heat exchanger tubes.

The data collected by OTEC-2, in conjunction with data from similar experiments conducted in Hawaii and the Virgin Islands, are expected to provide information vital to the development of large power plants capable of extracting the limitless solar energy stored in the oceans of the world.

OTEC power plants now under consideration generally are of a closed-cycle type in which a working fluid, such as ammonia, is used internally in a manner similar to the use of freon in a conventional refrigeration system. The ammonia is converted to a high-pressure vapor by exposing a large pipe containing the fluid to warm seawater near the surface. The vapor expands against the blades of a turbine inside the pipe, causing the turbine shaft--connected to an electric generator outside the pipe--to rotate.

After passing through and beyond the turbine blades, the vapor is condensed by exposing the pipe to cold seawater pumped up from the 3,000-ft level. Once again in liquid form, the ammonia is reheated by the warm surface seawater, thus beginning the cycle again.

Operational OTEC plants in the Gulf of Mexico would provide a substantial additional electrical power source for Gulf Coast States, thus reducing the nation's dependency on oil. Other possible uses of these power plants include the production of metals and chemicals from seawater and air which could then be transported to the continental United States by barge or ship.

DIRECTOR NWS RECEIVES IMO AWARD

Dr. George P. Cressman, Director of the National Weather Service, received the highest honor bestowed by the World Meteorological Organization--the International Meteorological Organization Prize.

The NOAA official was honored for "outstanding work in meteorology and international collaboration" in the improvement of global weather forecasting. The prize consists of a gold medal, a citation, and $1,200.

The presentation was made at the World Weather Building near Washington by Dr. David Arthur Davies, Secretary-General of the World Meteorological Organization, a specialized agency of the United Nations. In its announcement, the WMO cited Dr. Cressman for his participation in "international meteorological programs throughout his career," adding: "His pioneering work in numerical weather prediction was widely used throughout the world during the early development days of the electronic computer. The results of some of his other research work led to other operational uses with the computer." The announcement continued:

"Dr. Cressman has played a prominent part in the activities of the WMO. He served as the president of the Commission for Aerology, later renamed Commission for Atmospheric Sciences, from 1961 to 1965. When the WMO Advisory Committee was created in 1963, composed of outstanding experts in scientific and operational matters in the field of atmospheric sciences, and with broad terms of reference covering practically the whole field of interest of the WMO, Dr. Cressman was nominated a member of this Committee and was also its chairman during the first year."

Dr. Cressman became Director of the Weather Bureau on September 1, 1965. The Weather Bureau became the National Weather Service in October 1970.

UNIVERSITY OF WASHINGTON SEA GRANT TO STUDY FISHING VESSEL ACCIDENTS

The causes of fishing vessel sinkings and accidents will be studied by University of Washington scientists under a NOAA Sea Grant. The study, being done in cooperation with NOAA's National Marine Fisheries Service, could result in saving lives and millions of dollars worth of fishing craft, the scientists believe. The project is one of 51 to be pursued by Sea Grant scientists at Washington under the grant, which will be augmented by non-Federal matching funds.

The researchers plan to compile an extensive record of accidents involving commercial fishing vessels so that a permanent Fishing Vessel Safety Analysis Center, similar to the military's Aviation Safety Centers, can be established.

Cooperating in the collection of data will be the U.S. Coast Guard, underwriters, vessel owner associations, legal representatives, and individual fishermen.

Benefits of such a data base, say the researchers, will be availability of information from a single source, more accurate statistics, more effective safety programs, and wider dissemination of the underlying causes of accidents with anticipated reductions in losses of lives and vessels.

NOAA STUDY UNCOVERS PROPERTIES OF NEARSHORE ARCTIC SEA ICE

While offshore oil platforms set down in nearshore Arctic ice may not have to cope with excessive ice motion, the crushing strength of the ice may be quite different from the values predicted in present petroleum industry models, according to a NOAA study.

These recently analyzed results come from a continuing study of nearshore ice behavior along Alaska's northern coast conducted by the Army Corps of Engineers' Cold Regions Research and Engineering Laboratory under contract to NOAA.

The project is part of NOAA's Outer Continental Shelf Environmental Assessment Program, which is funded by the Interior Department's Bureau of Land Management to determine the probable ecological impact of oil and gas development on Alaska's outer continental shelf.

Exploring the small-scale world of ice crystals off the Beaufort Sea coast, the investigators found a strong tendency for the vertical axes of the crystals to align with prevailing current direction. This could cause important discrepancies between real ice-crushing strengths and those used by industry models, which assume sea-ice crystals have equal physical properties in all axes.

Monitoring ice motion with a high-frequency radar, the investigators expected to find a dominant ice-moving force in the Beaufort gyre, a westward-to-southwestward flow caused by the larger rotations of the Arctic Ocean gyre. But the sluggish currents--a mile or two per day--in the Beaufort Sea seemed to have little effect on ice movement. Significant horizontal motion of the ice--motion greater than about 300 ft--occurred only with sustained winds, and seemed largely independent of local currents.

The nature of ice motion in this area suggested large stresses were being exerted on the nearshore ice by the ice pack farther offshore. Fast ice--ice connected to the shore--out to about 4 mi (5 km) north of the islands was found to be relatively stable.

On the shoreward side of the islands, thermal expansion of the ice in spring seemed to dominate the small--5 ft or so--motions observed there. Stress cracking in the ice occurred with the motions of the order of 15 ft (5 m) or more, measured farther out to sea. It appeared that grounded ice in the shear zone between shore-fast ice and the ice pack helped stabilize the nearshore ice. In fact, the researchers attributed an observed increase in ice movement in 1977 over 1976 to less grounded ice in 1977, a warmer winter than 1976.

LIVING ORGANISMS FOUND INSIDE ANTARCTIC ROCKS

Scientists working for NASA and the National Science Foundation have discovered living organisms hidden inside rocks in the frozen deserts of the Antarctic.

The discovery--made in the Dry Valleys, a region whose harsh climate resembles conditions found on Mars--significantly extends the known limits of life on Earth, and also carries important implications for the search for extraterrestrial life. The discovery was made by a husband-and-wife team of Florida State University at Tallahassee who has been searching for microbial life in rocks for more than 15 yr.

The newly discovered microorganisms--bacteria, algae, and fungi--have been isolated and are growing in laboratory cultures, where they are being studied for clues to the secret of their endurance. Living cells have been found inside rocks in the hot desert areas of America, Asia, and Africa, but the Dry Valleys of Antarctica have long been regarded as lifeless. No plant or animal life is visible on the bare cliffs, and microbiological investigations of the soil--as well as theoretical investigations--indicated that they were lacking any native microbial life.

Although part of the "White Continent," the Dry Valleys region of the Antarctic is generally free of snow and ice, the combination of dryness and cold, as well as the nearly constantly blowing winds, results in an environment which is among the world's harshest. In this frozen brown desert, mountain ranges as high as 2,400 m (8,000 ft) alternate with valley floors, some of which contain permanently frozen lakes of high salt content.

Far from being lifeless, it was found that the Dry Valleys have a widespread rich microbial vegetation under the surface of rocks, in the air spaces of porous rocks, or in fissures. When the rocks are broken open, the organisms are seen as a dark greenish layer, a few millimeters deep. The tiny organisms take refuge from an unfavorable climate by occupying a microscopic niche where favorable conditions for life prevail. The microclimate between the minute grains of the rock may be quite different from the macroclimate outside.

Figure 45.--A rich microbial growth was found to exist inside the bare and apparently lifeless rocks from these sandstone cliffs in Antarctica. NASA Photo.

The organisms colonize light-colored semitranslucent rocks in which the intensive Antarctic sunlight penetrates several millimeters deep. Thus, while the temperature outside (and on the surface of the rock) may be well below freezing, inside the rock it may rise to relatively comfortable levels. The penetrating sunlight also provides energy for photosynthesis, while the uppermost rock layer protects the microorganisms from damage due to excessive radiation and drying up. Wherever the "proper" rock types occur, it is most likely that they are colonized by microbes, algae, or fungi (figs. 45 and 46).

NASA's Chief of Planetary Biology points out that the Dry Valleys in many ways approach the environmental extremes found on Mars by the 1976 Viking landers. These landers searched the Martian soil for signs of microbial life and organic molecules, apparently without success. If Martian life forms exist only in the interior of Martian rocks, as is principally the case in the Antarctic, that could easily serve as an explanation for the lack of evidence on Mars. Viking could not break open rocks and analyze the interiors. This interesting (if speculative) analogy is of considerable interest to NASA in designing future attempts to study planetary surfaces for evidence of life. If under these conditions of environment life is most likely to reside in the interiors of certain rock types, the design of the spacecraft would be influenced accordingly.

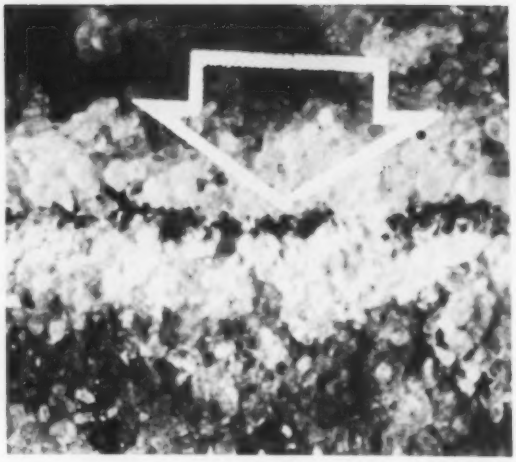


Figure 46.--This sandstone rock sample was magnified 10 times. When broken open, life was found which appears as a dark line about 1/40 in under the surface (arrow). The bright whitish zone underneath contains fungus filaments. NASA Photo.

PUBLICATIONS OF INTEREST TO MARINERS

NEW ENVIRONMENTAL DATA SOURCE DIRECTORY

Sponsored jointly by the National Science Foundation (NSF) and the National Oceanic and Atmospheric Administration (NOAA), Federal Environmental Data: A Directory of Selected Sources was compiled to assist individuals and organizations outside the Federal Government. Major environmental data bases maintained by U.S. Government agencies are described. Several systems, information centers, and programs that are themselves repositories of a large number of data bases also have been included.

Data bases operated by five Federal agencies are featured: the Department of Agriculture, Commerce, Interior, and Energy, and the Environmental Protection Agency. In addition, a few data sources from the Department of the Army, the National Library of Medicine, and the Council on Environmental Quality are described.

Listings in the Directory represent organized collections of scientific and technical data and bibliographic and directory information searchable by predefined terms. Each entry contains the following information: source name, source agency, objective, general description, size, update frequency, time reference, cost, user turnaround time, product, and person to contact.

A sample of the spectrum of environmental topics covered includes agricultural chemistry, crop improvement, plant genetics, ecology, marine biology, oceanography, meteorology, climatology, nuclear energy, public utilities, pollution, and environmental science.

A limited number of copies of the Directory are available from Dr. Louis Cima, OSIS Program, NSF, 1900 Pennsylvania Avenue, Washington, DC 20550. Telephone: 202-632-5800. Additional copies will be available in the spring through the National Technical Information Service, Springfield, VA 22161.

FOREIGN VESSEL RULES IN NEW COAST GUARD BOOK

The Coast Guard announced in late March that a single publication containing the bulk of its regulations for foreign vessels operating in U.S. waters will be available early this spring.

The document entitled, "Coast Guard Rules and Regulations for Foreign Vessels Operating in the Navigable Waters of the United States (CG-515)" will be obtainable only through a Government Printing Office subscription. The subscription service will include the basic publication and all periodic changes for the coming 3 yr.

When the new book is published, Commanding Officers of Coast Guard Marine Inspection Offices, Captains of the Port, and Coast Guard Marine Safety Offices will have preprinted order forms to facilitate public ordering.

As an initial step and until stocks of the order blank are exhausted, they will be given to all foreign vessels calling at U.S. ports by boarding officers, pilots, and shipping agents.

The new document will be available through normal Government Printing Office procedures as well.

MARINE WEATHER REVIEW

The SMOOTH LOG (complete with cyclone tracks [figs. 50-53], climatological data from U.S. Ocean Buoys [table 18], and gale and wave tables 19 and 20), is a definitive report on average monthly weather systems, the primary storms which affected marine areas, and late-reported ship casualties for 2 mo. The ROUGH LOG is a preliminary account of the weather for 2 more recent months, prepared as soon as the necessary meteorological analyses and other data become available. For both the SMOOTH and ROUGH LOGS, storms are discussed during the month in which they first developed. Unless stated otherwise, all winds are sustained winds and not wind gusts.

Smooth Log, North Atlantic Weather

November and December 1977

SMOOTH LOG, NOVEMBER 1977--This was a maverick month as far as the cyclone tracks and mean pressure pattern matching climatology. Normally, there is a track across the Great Lakes into the Labrador Sea and another from off the east coast of the United States to Iceland and beyond. This month the tracks were very scattered and diffuse. Storms from the northern plains moved toward Hudson Bay and Baffin Bay. Those that formed or traveled along the East Coast moved northeastward toward the Labrador Sea, except for one. A series of scattered cyclones formed over the central ocean and traveled in varied directions from northward to eastward.

There were few exceptions to the above. A storm from the northern plains of the United States crossed the Greenland Ice Cap near 68°N and then turned southeastward into northern Europe. A storm from the Pacific crossed southern Canada and the Atlantic before dissipating south of Iceland.

The primary center of the Icelandic Low was 994 mb and off the Norwegian coast near 69°N, 10°E. A secondary 1002-mb center was on the western coast of Greenland near 67°N, 55°W. The Bermuda-Azores High was split into two centers by a deep trough along 31°W. A 1022-mb center was just north of Madeira Island, and a 1024-mb center was near 38°N, 56°W.

The largest anomaly center was minus 14 mb near Stockholm in conjunction with the primary LOW. A minus 8-mb center was over central Greenland, and the trough in midocean produced a minus 4-mb anomaly near 40°N, 30°W. There were positive anomaly centers on both sides of this last negative center, which reflected the high-pressure cells.

The upper air flow between the two coasts was mainly zonal with the surface trough over midocean well reflected at 700 mb.

November 30 marked the official end of the 1977 hurricane season. There were six named cyclones: Anita, Babe, Clara, Dorothy, Evelyn, and Frieda. All but Frieda reached hurricane force. Although the season is over, storms have been observed in the Atlantic area during every month of the year except April.

Extratropical Cyclones--The first severe marine weather this month was associated with a high-pressure center, rather than a LOW as is the usual case. Actually, any strong winds have to be associated with both as a gradient is required and the terms are relative. This HIGH moved eastward from the northern plains of the United States to the province of Ontario and then southward across New England, where it again turned eastward. On the 1st the 1035-mb center was off Cape Cod near 42°N, 67°W. The coast south of Long Island was subjected to constant easterly winds blowing over a long fetch and creating higher than normal waves and surf. An Indian ship, the VISHVA ADITYA, out of Baltimore returned to Norfolk on the 2d with a 15° list after her cargo shifted. There was serious beach erosion along the exposed coastline. Ships off the coast were generally reporting 20- to 35-kn winds with the waves 8 to 12 ft. The High moved slowly eastward with little change in intensity. On the 5th a cold front crossed the coast with another HIGH centered over Ontario right behind. On the night of the 4th a barge carrying 2 million gal of liquid asphalt broke away from its tug and grounded 11 mi north of Hatteras on the outer banks (fig. 47).

This second HIGH continued the easterly winds along the southeastern coast. The air off the ocean was laden with moisture, and heavy rains east of the Appalachian Mountains brought flash floods to the area. On the 6th an earthen dam in Georgia failed, and 33 persons lost their lives. As the HIGH moved off Maine, it dissipated; but another was following in its tracks.

Figure 47.--Water sweeps over this barge carrying liquid asphalt which grounded 11 mi north of Cape Hatteras. Wide World Photo.

A LOW that had been stationary over the Gulf coast started moving northward on the 6th. A tropical depression that had formed south of Bermuda was moving northwestward toward Cape Hatteras on the 6th and 7th. The more intense gradient and higher winds were north of Norfolk. Wind gusts of over 50 kn were measured along the New Jersey coast. The HIGH moved over Nova Scotia and to sea on the 8th.

This storm came off the Pacific and retained its identity as it raced across the continent. It crossed the coast of British Columbia at 1800 on the 1st and crossed the Labrador coast at 1500 on the 4th. The 976-mb center passed south of Kap Farvel on the 5th. At 0000 on the 6th, OWS Charlie measured 40-kn gales and 20-ft waves. The C.P. TRADER was at 53°N, 30°W, 12 hr later, with the same 40-kn gales, but the waves had increased to 23 ft. At 0000 on the 7th, she was headed into 30-ft swells from the west. The ERNST KRENKEL was farther southwest of the LOW near 50.5°N, 35°W, with 25-ft seas. The 1200 chart with more observations indicated waves up to 15 ft as far as 1200 mi south of the center. Charlie now had 26-ft seas, and the FCCV was caught by 50-kn winds in the vicinity of 43°N, 39°W, ahead of a minor trough. The LOW was southeast of Iceland on the 9th when it disappeared.

The trough referred to in the narrative above developed a closed LOW on the 0000 chart of the 8th. In 12 hr the pressure plunged to 978 mb near 41°N, 38°W. The OPALIA at 38°N, 45°W, was caught by 50-kn winds and 20-ft seas. The ALLISON LYKES passed the front heading westward and found 36-ft swells. On the 9th at 1200 the 965-mb center was near 48°N, 30°W. The TEMPLE INN (41°N, 43°W) contended with 55-kn winds and 38-ft seas. Another ship 400 mi south of the center had 50 kn and 33 ft. OWS Romeo monitored 26-ft seas at 0000 on the 9th. High seas continued through the 10th and 11th with the winds 40 to 50 kn. Mountainous waves on the Irish Sea swept away a pier at Morecambe, England (fig. 48). Gale-force winds and heavy rains caused flooding and the evacuation of many homes. On the 12th the primary center shifted to what had been a secondary LOW. This LOW moved eastward across Scandinavia into the U.S.S.R.

Another exception to the general run of storms. This was the one that crossed the Greenland Ice Cap. It had its origin over the Midwest on the 9th and rapidly consolidated the circulation as it moved northward prior to turning toward the Great Lakes. The 994-mb center was over Lake Superior at 1200 on the 10th when gale warnings were posted for both Lakes Superior and Michigan. At 1200 on the 12th the 976-mb center was over Cape Chidley. A station on the west side of Ungava Bay reported bone-chilling, 40-kn northwesterly winds. Later in the day a ship north of Hamilton Inlet braved 58-kn winds and 20-ft seas. On the 13th a Danish ship off Holsteinsborg

Figure 48.--Waves lash the remains of the pier at Morecambe after mountainous waves swept part of it away. Wide World Photo.

(67°N) found 52-kn northerly winds at -4°C. By 1200 the storm had survived crossing the Ice Cap and was 970 mb over Denmark Strait. OWS Lima measured 40- to 50-kn winds for the next 24 hr with seas over 25 ft building to 38 ft by 1200 on the 14th. At 0000 on the 14th Angmagssalik measured 80-kn downslope winds from off the Cap. At 1200 the LOW was 958 mb north of the Shetland Islands. Several ships had seas or swells over 30 ft, and the fleet on both sides of Scotland suffered 45- to 60-kn winds.

The LOW was traveling southeastward and passed south of Oslo on the 15th. The SOULOI was west of Ireland, far from the center (54°N, 17°W) with roaring 75-kn winds and 24-ft seas. Lima had 33-ft seas. By the 16th the high winds and seas calmed as the LOW moved into Finland.

A front out of a LOW over Davis Strait lay north-south along 45°N on the 20th, and a wave developed near 44°N, 46°W. At 1200 on the 21st it was 990 mb near 50°N, 49°W, a small tightly wound storm that was moving northward between two 1032-mb HIGHs. The WESER EXPRESS was about 100 mi southeast of the center with 40-kn gales and 16-ft waves. At 1800 a SHIP off St. John's battled 55-kn northwesterly winds. On the 22d the LOW dissipated as fast as it had developed.

This LOW formed in the same small col area as the previous one, only farther south, at midday on the 21st. On the 22d it was 990 mb near 40°N, 47°W. The HAHENTOR was southwest of the LOW with 46-kn gales and 26-ft swells. As the last storm died, this one absorbed part of its circulation. Winds of 35 to 40 kn were found both north and south of the center with seas to 20 ft on the 23d. There were also two reports of 50 kn winds. A second center had formed 300 mi to the south. On the 24th the ACHILLES at 36°N, 44°W, was struck on the heels with 26-ft seas. The LOW had now split into two separate centers. On the 24th the storm reached 55°N and turned sharply eastward. The ANNA JOHANNE (58°N, 45°W) had 53-kn northeasterly winds and 26-ft seas. Twelve hours later the winds were 60 kn and the seas 30 ft. Ships south of the LOW had 35 to 45 kn and 20- to 25-ft seas. The AMERICAN ARCHER (47°N, 42°W) was slammed by 50-kn winds and 33-ft seas and swells. The northern LOW continued northward and grounded north of Kap Farvel on the 26th, while the southern center turned eastward. During this period a SHIP near 53°N, 35°W, reported winds to 50 kn and seas to 23 ft. The southern center departed from the analysis on the 26th with the northern one following on the 27th.

The high pressure that normally sits over the Greenland Ice Cap started drifting southward on the 20th. A trough formed over the Denmark Strait on the 21st, and a LOW was analyzed on the 22d. Late that day three Icelandic ships north of the island were tossed about by 50-kn winds which continued into the 23d. At 1200 that day the LOW was centered near 65°N, 03°W, at 980 mb. The EDITH NIELSEN (60°N, 19°W) had 45-kn winds and 30-ft seas on her starboard bow. A ship north of Ireland was swept by 45-kn winds and 23-ft seas. On the 24th two ships in the North Sea near 53°N, 02°E, were mauled by 60-kn winds, but no seas were reported. The NAUTIK was fishing east of the Orkney Islands when she was hit by 60-kn winds and 39-ft seas. By the 26th neither LOW was significant.

A cold front moved off the Gulf and Southeast coast early on the 25th and stalled as they often do for various reasons. Over the Gulf this is usually the result of the lack of any wind component normal to the front. The same applies over the Atlantic, but as in this case a large high-pressure area may also have impeded further movement. In this type of situation waves will generally form on the front as they did on the 25th off South Carolina. The storm moved up the coast, deepening as it went. By 1200 on the 27th, the 974-mb center was west of Sept-Isles. Two Canadian vessels in the vicinity of 44°N, 64°W, were on the receiving end of 50- and 55-kn winds. EB07 now named 44007 reported 40-kn winds and 21-ft seas. At 1800 the AMERICAN ARCHER, 100 mi east of Cape Sable, experienced 55-kn winds, 16-ft seas, and 33-ft swells. On the 28th the IMPERIAL BEDFORD outside of Cornerbrook had 60-kn winds. Other ships were finding 40 to 50 kn and seas to 25 ft. On the 29th the storm moved ashore near Godthab, Greenland.

As the LOW above crashed on the Greenland shore, a LOW formed in a trough near Cape Sable. The 1002-mb LOW was near 48°N, 43°W, at 0000 on the 30th. The OGDEN FRASER near 42°N, 46°W, was washed by 50-kn rain-laden winds. The winds were gradually increasing, and on December 1 the 954-mb maelstrom was near 54°N, 35°W. Winds during that period were up to 60 kn and the seas to 30 ft. The DART EUROPE, MANCHESTER CHALLENGE, and TROLL PARK south and west of the LOW were among those reporting. On the 2d the central pressure started rising and the circulation spread, relaxing the gradient and the winds. Twenty-foot seas were still found up to 1,000 mi to the south. On the 3d the center turned northwestward, and OWS Charlie was swamped by 25-ft swells. As the LOW approached Kap Farvel on the 4th, it disappeared.

Casualties--The American tank barge MORANIA No. 200 (3,546 tons) went aground in rough seas north of Avon, N.C., on the 4th while in tow of the tug CRUSADER. The British 4,493-ton roll-on/roll-off HERO was abandoned in heavy weather near 54.5°N, 05.6°E, on the 12th. Vessel reported sank on the 13th. One crewmember died. The Faeroe Islands cargo vessel STAR SEA (392 tons) arrived St. John's, Newfoundland, on the 18th with a ventilator cap missing due to heavy weather. The 1,600-ton Danish DECIMUS was at Nassau on the 22d and reported containers lost overboard and hull damage from heavy weather. The 2,713-ton laker VIKING pulled out dock mooring fittings, disturbed apron, and struck the knuckle at a dock at Frankfort, Mich., in strong winds on the 21st. The Greek cargo vessel LADY ERA (8,109 tons) went aground on rocks in 11 ft of water at Seven Islands and developed a 12° list. Gale-force winds with 12-ft swells hindered rescue efforts. The Liberian-registered 8,537-ton NEWARK grounded during a strong gale off Tripoli, Libya. On the 26th the Greek AGIA ELENI (980 tons) broke her mooring ropes while at Rhodes and was stranded on rocks. The 1,439-ton Cypriot freighter SAN GEORGE was blown aground on the 27th at Istanbul. fig.).

SMOOTH LOG, DECEMBER 1977--There were not as many significant LOWs over the waters of the North Atlantic as normal. The primary storm path was from the Great Plains States across the Great Lakes to the Hudson Strait. There were secondary tracks along the East Coast of the United States toward Newfoundland and from the central ocean near latitude 50°N northeastward to eastern Iceland. One storm tracked from North Carolina to Ireland and Scandinavia. The climatological primary tracks are from the Great Lakes to near Cape Cod to the Labrador Sea and south of Newfoundland to Iceland.

The monthly mean pressure pattern differed from the climatological pattern as would be expected. The one feature this month that compared favorably with climatology was the primary Icelandic Low. It is normally positioned near 62°N, 30°W, at 1000 mb. This month it was 998 mb near 58°N, 37°W. The cyclonic circulation over the northern waters differed from climatology near the position of the secondary Low. It is usually over the Norwegian Sea at 1001 mb between Iceland and Norway. This month it was 1000 mb over Nova Zemlya. The Bermuda-Azores High at 1022 mb was centrally located over the ocean near 28°N, 47°W, about 1,200 mi southwest of its climatic position. This westerly shift of the High resulted in a trough off the west coast of Europe.

It was in association with this trough that the major negative anomaly occurred at minus 7 mb. Central Europe was dominated by a positive 9-mb anomaly. There were two other positive centers--a 4 mb over the ocean near 25°N, 48°W, and a 6 mb near Cape Chidley. The pressure over the north-central United States was below normal with a center over the Great Plains and another over the Great Lakes.

The upper air flow was mainly zonal over the western ocean. The sea-level trough over the eastern ocean was reflected in the higher levels off Europe. with a ridge alined along longitude 10°E.

The annual article describing the North Atlantic tropical cyclones for 1977 appears in the March issue.

Extratropical Cyclones--This was a series of relatively small cyclones that formed in a large cyclonic circulation that was centered over midocean near 55°N. As the last storm described in the November Log approached Kap Farvel, another LOW formed near 48°N, 35°W, late on the 3d. The MEYNELL was in the southwestern quadrant with 55-kn westerly winds. By midday on the 4th the 970-mb LOW was at 52°N, 25°W. Ships south and west of the center were reporting 40- to 50-kn winds with seas and swells to 23 ft. At 0000 on the 5th, the SQHF was near 46°N, 37°W, or about 700 mi southwest of the center with 65-kn winds. Later in the day the storm turned toward the north with gales and 20-ft seas south of the center. The C.P. DISCOVERER (54°N, 29°W) was sailing into 76-kn winds and 20-ft waves. On the 6th the storm was heading northwestward, and another center formed off Lands End. This center crashed onto the Greenland coast on the 8th.

A shallow, ill-defined LOW had tracked across the United States to the East Coast, but it could not be analyzed on the charts of the 4th. On the 5th it appeared to redevelop south of Newfoundland. By 1200 it was 990 mb near 44°N, 40°W. The HANNOVER about 180 mi south of the center was battered by 65-kn winds driving 26-ft seas and swells. Six hours later the SQHF and STOLT LLANDAFF were straddling the center with the same 984-mb pressure and 84- and 60-kn winds, respectively. On the 6th another small center developed east of this one. The gradient and windspeeds relaxed in that quadrant, but they increased in the western quadrant. The tug BILLY B. put into Vigo, Spain, on the 6th after heavy weather washed off some of her tank covers. The same three ships named above were caught with 50- to 65-kn winds. The HANNOVER reported 56-ft swells near 41°N, 41°W, and the STOLT LLANDAFF reported 44-ft swells near 45°N, 39°W. By the 7th a new cyclone absorbed both this LOW and the one that had previously formed near Lands End. At 1200 this consolidated storm was 972 mb south of Fastnet Rock. There were reports of seas and swells of 25 to 43 ft as far away as 900 mi southwest of the center. Winds were over 50 kn. On the 8th it brought winds of 50 to 60 kn and seas to 30 ft to the North Sea. On the 9th the storm was incorporated into a large deep storm that was approaching from the west.

This storm formed over the Red River Valley of Texas and Oklahoma on the 4th. Late on the 6th it moved off the East Coast near Cape Cod. By midday on the 7th, the storm was 970 mb over Cape Breton Island. The EXXON HOUSTON was headed for Norfolk into 50-kn winds and 20-ft seas. The CEDARBANK at 35°N, 70°W, was fighting 60-kn westerly winds and 33-ft swells.

On the chart of 1200 on the 8th a new center had formed east of the original one, and it was even more intense at 960 mb near 49°N, 48°W. The LAURENTIAN FOREST was south of the original center with 50-kn winds and 30-ft swells. Other ships reported 50- to 60-kn winds with smaller waves. The STOLT LLANDAFF was swamped by 39-ft swells near 44°N, 45°W. On the 9th the PROTSIONE near 47°N, 42°W, was holding her bow into 60-kn northwesterlies. A ship reported a thunderstorm with 50-kn winds along a trough line, while another had 26-ft seas. The TANAFJORD (51°N, 44°W) contended with 60-kn winds and 30-ft seas. Ocean Stations Charlie and Romeo were tossed by seas up to 30 ft on the 10th.

The storm was now moving toward the Faeroe Islands at 962 mb. The area on the charts south and west of the center was cluttered with sea and swell reports over 20 ft. The highest swell was 39 ft reported by the KORRIGAN about 850 mi southwest of the LOW. Winds of 60 kn were reported by the C.V. LIGHTNING. The center passed within a few miles of OWS Lima. On the 12th it was absorbed by another vicious storm.

Lake Huron was the spawning ground for this storm. Strong southerly winds were blowing off the U.S. East Coast by late on the 9th. At 1200 on the 10th the central pressure was 970 mb over Anticosti Island in the Gulf of St. Lawrence. A British ship experienced 50-kn winds with 36-ft seas near 41°N, 58°W, just east of the front, and a Canadian ship had 52-kn winds in the Gulf as she registered a pressure of 977 mb. As the storm moved over the Labrador Sea, it deepened to 955 mb on the 11th. A minus 5°C wind was blowing at 50 kn in the Strait of Belle Isle. Swells of 20 ft were reported along latitude 44°N from 60° to 30°W. A ship reported 60-kn winds and 25-ft seas near Sable Island.

Later, the swell waves increased to 33 ft. On the 12th the LOW was approaching Kap Farvel. South of the center the RAVA RUSSKAYA encountered 50-kn winds and 38-ft swells. OWS Charlie measured 28-ft seas. By early on the 13th the swells had increased to 31 ft. Later that day the storm dissipated.

This storm tracked along the United States-Canadian border and moved out to sea near Portsmouth, N.H., on the 15th. It tracked along the coast, and at 0000 on the 16th the pressure was 986 mb. The CHEBUCTO (43°N, 65°W) was battered by 80-kn winds from the northwest. South of Newfoundland three ships reported winds near 50 kn with two measuring swell waves of 30 ft. On the 17th the LOW circled over Newfoundland as another center formed near 40°W. A ship found 23-ft swells between the two centers, which were rotating around each other on the 18th. The maximum wind appeared to be about 45 kn. When the chart of 0000 on the 19th was analyzed, only one 982-mb center could be found. The CHEVRON AMSTERDAM 600 mi south of the center near 36°N, 47°W, was sailing into 50-kn winds. On the 20th the circulation of the 968-mb LOW dominated the Atlantic from Iceland south to 25°N and from Newfoundland to Europe. Several ships had reported 50-kn winds with one swell report of 31 ft at 50°N, 45°W. The Soviet ship ARAGUI (40°N, 35°W) was pounded by 33-ft seas and 50-kn winds. North of the LOW, Icelandic fishing boats were fighting winds as high as 60 kn.

The LOW split into two centers on the 21st with the new one destined to become the primary center. The C.P. TRADER was caught near the center with 966-mb pressure, 45-kn winds, 25-ft seas, and 33-ft swells. Charlie was nearer the center with light winds at 965-mb pressure and 21-ft swells.

The storm consolidated again on the 22d as another storm moved around the southern perimeter. The DART AMERICA was stationary at 45°N, 37°W, with 50-kn winds, 21-ft seas, and 39-ft swells. The 966-mb LOW was still very close to Charlie with the 20-ft swells continuing. The LOW picked up speed on the 23d and disappeared on the 24th over the Norwegian Sea.

As far as the marine community is concerned this was an inland storm, except over near-shore waters. The LOW originated north of Hawaii along latitude 35°N on the 15th. It maintained its identity across the Rocky Mountains and intensified over the central Plains on the 19th. At 1200 on the 21st the storm was 1000 mb over Lake Michigan. Storm warnings for winds in the 50-kn category were posted for Lake Huron with gale warnings for the remainder of the Lakes. A second LOW formed over the Carolinas at the point of occlusion. Four ships foundered or sank in the Chesapeake Bay and along the Maryland-Virginia-North Carolina shoreline. Crews from three of the craft, tugboats towing barges, were rescued. The tanker AEGIS PRESIDENT sprang a leak off Cape Henry. High seas battered resort centers along the Delmarva Peninsula. A newspaper reported seas as high as 60 ft. Four Navy ships returning to Norfolk from the Mediterranean were delayed a day in arrival owing to the severe seas. Late on the 22d the storm again consolidated into one center over James Bay and continued northward to Cornwallis Island.

Monster of the Month--This LOW developed over North Carolina on the 18th at the intersection of a complicated frontal system. It was also the LOW that rotated around the periphery of the storm described above and was the most southern of the significant storms. It paralleled 35°N to 30°W, where it turned north-northeastward.

At 1200 on the 19th, the 989-mb center was near 36°N, 71°W, with the strongest winds north of the center. The 7,022-ton tank barge POSEIDON broke tow of the tug TEXAN off Cape Hatteras. The crew of nine was rescued. Two ships within a degree of latitude of 39°N, 72°W, one was the CHEVRON ARNHEM, reported winds of 50 and 55 kn with seas as high as 26 ft. At 1400 the EDGAR M. QUEENY at 37.5°N, 74.3°W, was northwest of the center with 25-ft seas and 35-ft swells. On the 20th, the tight gradient had expanded to the west side of the LOW, and the LORD D'ORLEANS found 33-ft seas and 41-ft swells near 36°N, 75°W. The OVERSEAS ULLA was nearby with 36-ft seas. The DILOMA was pounding into 60-kn winds and 33-ft waves. A ship reported a thunderstorm on the 0000 chart of the 21st, while not far away the JOANA had 68-kn winds out of the southwest. The 2,588-ton Greek SUMMER BREEZE ran aground on rocks off Povoacao, St. Michael's, Azores, after developing boiler trouble in bad weather. The crew abandoned the ship. At 1800 the GREEN VALLEY was engulfed with 56-kn winds and 30-ft seas while 200 mi south of the LOW. The FRESNO CITY encountered heavy weather enroute to Balboa; deck cargo of lumber was partially lost. On the 22d the center was 990 mb at 35°N, 31°W. The SNOWLAND was 500 mi to the west-southwest with 31-ft seas. Closer to and more south of the center, 60-kn winds and 30-ft seas were reported by the WORTH.

When the storm turned northward on the 22d, it picked up speed and by 1200 on the 23d was 978 mb almost directly over Ocean Weather Station Romeo. Her winds were 40 kn and seas 20 ft. The SUN PRINCESS reported heavy weather damage on the 21st and 22d on arriving at Balboa on the 23d. The EXPORT COURIER had 60-kn winds and 18-ft seas near the Azores. Later in the day the BREMERHAVEN, not long out of the English Channel, was sailing southwestward into 60-kn winds and 26-ft waves. On the 24th the storm moved over the North Sea bringing 50- to 60-kn winds to that body of water. The Belgian tank ship LAGUANA rammed a breakwater in high winds and sank with the loss of a woman and three children. As hurricane-force winds lashed the coasts of England, Ireland, Holland, and Denmark, six people drowned in the churning seas, and seven more were feared to

have drowned. The 500-ton LADY KAMILLA sank off southwest England. The 3,500-ton EAST BIRD II went adrift off Wales, and the 2,440-ton RAFAELA went aground off the east coast. Many trees were uprooted with extensive property damage. Devon reported 87-kn gusts and London had 65 kn. The storm moved into western Russia on the 25th.

A description of good weather in December for a change! A cell of the Bermuda-Azores High off the southeast coast of the United States started drifting northeastward on the 23d. It increased in pressure as it moved, and by the 26th it was the primary high-pressure center over the North Atlantic. On the 26th the central pressure exceeded 1040 mb, and by the 28th it was analyzed at 1051 mb near 47°N, 33°W. The WALTER ULBRICHT reported the highest pressure of 1049.8 mb at 0000 on the 28th near 48°N, 31°W, with a 10-kn northerly wind. The 1050-mb center was analyzed a few miles west of that position. LOWs were being deflected northward off the East Coast or were over the Greenland Sea. It was the 31st before the pressure dropped below 1040 mb. This brought good weather for a large portion of the North Atlantic and the major shipping lanes during the last week of the month. Accurate climatological records for high-pressure records over the oceans could not be found; but this probably approaches the record over the ocean, where the pressure does not get as high as it does over the continents. The highest pressure for the world is 1083.8 in Siberia, and for the United States it is 1063.6 in Montana.

This was one of the storms which the high pressure kept far to the north. It formed on the Greenland coast near Scoresby Sound (70°N) on the 28th and moved eastward. At 1200 on the 29th it was near 70°N, 03°E, at 960 mb. Winds of 40 kn were measured on the east coast of Iceland. Fishing vessels around the island were reporting 50-kn winds and 20-ft seas. The northwesterly flow covered the North Sea and the United Kingdom. Late on the 30th various vessels and platforms in the North Sea were reporting winds up to 60 kn and seas to 36 ft. On the 31st the ZARIA took the award for 38-ft seas near 56°N, 01°E. By late in the day the LOW had crossed the Baltic Sea and was heading inland.

Casualties--The Italian MICHELE GAROFANO (1,588 tons) grounded on the breakwater in heavy weather at Benghazi on the 2d. The Greek-registered BALTIC EAGLE (1,562 tons) sprang a leak, broke in two, and sank during heavy weather about 230 mi east of Angra in the Azores on the 7th. Five crew were missing. The 4,558-ton Panamanian LORNA I passed Istanbul on the 10th with no news since. It is feared that the vessel sank because of heavy weather in the area. Wreckage marked INYULA, a former name, and four bodies were found. There were 21 crewmembers on the ship. The roll-on/roll-off vessel JASMINE developed an extreme list in heavy seas 40 mi off Haifa on the 9th and returned to Haifa on the 13th. It was reported that the 109,522-ton British tanker E. HORNSBY WASSON sustained minor heavy weather damage on the 12th while on a voyage to the Bahamas. On the 18th the 5,921-ton Danish HETLAND RANGER suffered slight damage as did the pier while unmooring in strong winds in Nova Scotia.

The 12,039-ton British MANCHESTER CRUSADE encountered heavy weather during passage to Montreal December 9 to 16. The American Great Lakes bulkcarriers GEORGE D. GOBLE and the Canadian GODERICH became stuck in ice on the 11th in the outer channel to the Detroit River. The 8,798-ton bulkcarrier HENRY FORD II became stuck in ice while 1 mi below Detroit River Light on the 21st. The cargo vessel ROMAN PAZINSKI, Europe to East Coast, lost containers overboard. The 1,157-ton British CONQUEROR ran aground at Penzer Point, Mount's Bay, on the 27th. The crew was taken off.

This was either a South Atlantic or an Indian Ocean accident. In what may have been the costliest collision to date, the two sister ships VENOIL and VENPET (both over 330,000 tons) collided about 80 mi south of Port Elizabeth. There was a report of fog in the area. The VENOIL was laden with over 75 million gal of crude oil, and the VENPET was in ballast. Both ships caught fire and were abandoned by the crews. Eighty-four of the 86 crewmembers were saved by nearby vessels and a helicopter. The fires were extinguished and both vessels taken in tow.

Smooth Log, North Pacific Weather

November and December 1977

SMOOTH LOG, NOVEMBER 1977--Both oceans were anomalous with the normal climatological patterns this month. This is an indication that meteorology is a continuous phenomenon and not an isolated condition. Like the North Atlantic the concentration of storm tracks was shifted eastward. In this case the primary track originated in midocean along latitude 35°N and moved toward the Gulf of Alaska. Storms from the vicinity of Japan were widely scattered and traveled in various directions. Normally, the concentration of paths is from Japan to the Bering Sea and south of the Aleutians into the Gulf of Alaska.

The Aleutian Low was normal at 1002 mb near 53°N, 160°W. A trough oriented south out of the Low split the Pacific High into two 1023-mb centers--33°N, 133°W, and 33°N, 165°E. These centers were 3 to 5 mb higher than climatology. There was a large negative anomaly centered on 160°W from the Aleutians to latitude 20°N. A positive 4-mb anomaly was centered off the California coast, and a positive 9-mb center was southeast of the Kamchatka Peninsula. These two positive centers reflected the higher pressures in those areas and the abnormal paths of the cyclones.

The upper air pattern at 700 mb had an anomalous

LOW over Bristol Bay with a sharp trough south along longitude 170°W. As with the surface, this split the HIGH into two centers.

There were two typhoons, Kim and Lucy, over the western ocean.

Extratropical Cyclones--This LOW formed south of Kodiak Island in a trough associated with another LOW over the Bering Sea on the 5th. The MARITIME FORTUNE was off Portland, east of a sharp ridge ahead of the front, with 56-kn winds on the 6th. The ALASKA was near Yakutat with 55-kn winds. At 0000 on the 7th, the 991-mb LOW had crossed the mountains into northern Canada, and another 994-mb center was near Valdez. The MOBIL MERIDIAN and NEWARK were south of the Valdez center with 45- and 50-kn winds and 25- and 26-ft swells, respectively. Other ships found 40-kn winds and 20-ft waves. The LOW was stationary over Valdez, and on the 8th the GALVESTON headed toward Seattle contributed a 50-kn wind report. By the 9th the storm no longer existed.

A LOW out of Manchuria moved over the Sea of Okhotsk on the 6th. On the 7th another LOW formed at the point of occlusion on the east coast of the Kamchatka Peninsula. It moved slowly eastward and at 0000 on the 8th was 984 mb near 56°N, 172°E. The EASTERN RELIANCE at 50°N, 168°E, had 45-kn winds with 14-ft seas. Ahead of the front at 54°N, 172°W, the LIONS GATE BRIDGE had 44-ft swells pounding her portside. The ALEUTIAN DEVELOPER near 56°N, 158°W, fought 55-kn southerly winds and 20-ft seas 24 hr later. In the southwest quadrant there were 40-kn winds and 16-ft seas. On the 9th at 1800 the GALVESTON had 60-kn southeasterlies near the Alaska coast. Winds of 40 kn and seas of 16 ft were still southwest of the center. The storm crossed the Alaska Peninsula into the Gulf of Alaska on the 9th. On the 10th it curved northward and dissipated over the mountains of the Alaska-Canada border on the 11th.

This frontal wave formed between two high-pressure cells on the 7th near 34°N, 167°W. The pressure gradient between the LOW and the western HIGH was supporting 40-kn winds and 24-ft seas by 1200 on the 7th as found by the PRESIDENT JEFFERSON. By 0000 on the 8th the LOW was near 41°N, 155°W, as the eastern HIGH retreated rapidly eastward. Winds on the western side of the LOW continued at 40 to 45 kn with one report of 20-ft seas. On the 9th the PRESIDENT MADISON off Sitka had 50-kn winds. The LOW moved onto Vancouver Island and died.

The Yellow Sea produced this storm. It began as a frontal wave on the 7th, the third one to start on this day. It raced across the Sea of Japan and on the 9th was over the Kurile Islands. A ship south of the center and near the cold front had 16-ft seas. Another near Ostrov Kunashir reported 50-kn winds. At 1200 the SUCHAN (50°N, 155°E) was holding her position in 50-kn winds and 26-ft seas. On the 10th a U.S.S.R. ship in the Gulf of Shelekhov in the Sea of Okhotsk had to halt operations in 80-kn easterlies. The KATHRYN MARU was 500 mi south of the center at 1200 with 26-ft seas. At this time another center formed to the east, and by the 11th this LOW was gone.

This LOW was frontal generated on the 10th near 35°N, 146°E. It raced northeastward, still a small storm. At 1200 on the 11th it was 998 mb near 46°N, 170°E. Four ships south and west of the center reported 48- to 54-kn winds and seas up to 20 ft. On the 12th a ship near Mys Lopatka was swamped by 28-ft seas. Late in the day the PRESIDENT MADISON near 50°N, 176°E, was headed into 60-kn winds and 25-ft swells. On the 13th two ships southwest of the center had 50-kn winds, and the seas were reported as high as 25 ft. At 1200 the 966-mb center was over the Alaska Peninsula. At 1800 the SINCLAIR TEXAS was headed southeastward into southerly 60-kn winds and 30-ft waves. Ocean Weather Station Papa was fighting 54-kn winds and 18-ft seas. By the 14th another LOW had absorbed the circulation, but this had little to do with the actual weather. Over a half dozen ships reported winds between 45 and 60 kn on the 14th with seas to 30 ft. The EXXON SAN FRANCISCO was near 51°N, 133°W, at 1800 with 33-ft seas and 39-ft swells. The storm brought intense rain to the Oregon and Washington coasts. Winds gusted to as high as 67 kn at Smith Island, Washington, on the inland waters. Other stations reported gusts over 50 kn. On the 15th the weather improved, and the storm was no longer a problem.

Late on the 14th a LOW developed off the Kamchatka Peninsula. At 1200 on the 16th it was 970 mb near 55°N, 173°E. The WORLD SUPREME was north of Unimak Island and was ravaged by 86-kn winds out of the southeast. Two ships south of the center had 60-kn winds and 33-ft swells. The center was moving very slowly. The INACHUS STAR at 52°N, 170°E, churned into 50-kn winds and 33-ft swells. Late on the 17th this storm was absorbed by the one below.

A front stretched unbroken from the northern California coast to Taiwan. On the 0000 chart of the 15th a wave was analyzed near 33°N, 149°E, using the observations from a Japanese and a German ship. The frontal wave was under strong westerly zonal flow aloft and raced to 175°W in 36 hr. Along the way several ships reported gales and waves to 23 ft. The GEORGIANA, near 36°N, 174°W, about 150 mi south of the center, was battered by 55-kn winds with 49-ft seas and swells. At 0600 on the 17th, the ILLINOIS and another American ship had 50- to 55-kn winds and 30- to 33-ft swells, not far from 41°N, 168°W.

On the 18th this storm combined with the previous storm near 50°N, 170°W, at 966 mb. The EURYALUS and the GEORGIANA were near 36°N, 177°W. The winds were 45 kn and the seas and swells 36 to 43 ft. The ALEUTIAN DEVELOPER south of Unimak Island had 65-kn winds out of the southeast with 33-ft seas. At 0000 on the 19th the storm was still 966 mb near 55°N, 180°. The LOW was stationary for the next few hours over the Bering Sea. Very few ships were reporting. On the 20th at 1200, the ALEUTIAN DEVELOPER was sailing northeastward near 57°N, 154°W, with 50-kn easterly winds and 30-ft swells. On the 21st the storm was moving northwestward toward oblivion.

Late on the 15th this storm formed over the Yellow Sea. As the last frontal wave, it raced eastward under

the strong upper air flow. Along the way it produced heavy rain and some gales. On the 19th it was 995 mb near 37°N, 179°W. The FUJISAN MARU was caught near 32°N, 178°E, with 45-kn gales and 15-ft waves. On the 21st the storm reached latitude 46°N and was turning northwestward. A ship near 48°N, 150°W, which was east of the center, had 26-ft swells pounding her portside on her southerly track. North of the LOW two ships had 40-kn gales and 20- to 24-ft seas. At 1200 ocean buoy 17 measured 40-kn gales and 25-ft seas. Late on the 22d, the storm was overtaken by the next storm.

This LOW formed over midocean near 40°N, 173°E, on the 21st. At 0000 on the 22d it was 977 mb near 41°N, 167°W. The GOLDENROD was near the center at 41°N, 170°W, with a pressure of 980 mb, 70-kn winds, 26-ft seas, and 41-ft swells. At 0600 the UIWK reported 82-kn winds with 20-ft seas a few miles south of the center. The ARCO PRUDHOE BAY was far to the north at 55°N, 145°W, with only 45-kn easterly winds, but the swells were 25 ft. At 0000 on the 23d the 974-mb center was rolling toward the northeast and hit the SANTA MONICA MARU with 50-kn winds and 24-ft swells. At this time the storm's circulation covered the ocean north of 25°N and east of 175°E. Winds up to 50 kn and swells to 33 ft continued. The OVERSEAS NATALIE was sailing eastward near 47°N, 169°W, into quartering 34-ft swells. The PHILADELPHIA (55°N, 141°W) northeast of the center was bounced by 30-ft swells. The LOW disappeared south of Seward, Alaska, on the 26th.

This storm formed near 36°N, 173°E, around the remnants of an old weak front. By the 25th it had organized, and the IRVING WOOD and POST CHASER had winds of 50 kn or better and seas as high as 30 ft west of the storm. Later on the 25th another LOW formed west of this one, and a ship was caught in 50-kn winds and 24-ft seas. In the southerly quadrant between the two centers there was another report of 26-ft swells. The western LOW was to become the stronger of the two. At 0000 on the 26th, the PACPRINCE was 200 mi southwest of the second LOW (36°N, 177°W) where she caught 39-ft swells with 50-kn winds. Twelve hours later ships reported 36-, 30-, and 24-ft swells about 600 mi west of the storm. The highest winds were 55 kn. The first LOW was racing northeastward, and a ship at 38°N, 155°W, found 50 kn and 24-ft seas and swells.

The LOWs were following each other as on a race track. The first LOW had passed too far east of the JAPAN BEAR to affect her, but she was caught by the second storm with 50-kn winds and 24-ft waves. The first storm dissipated late on the 27th as it hit the British Columbia shore. The second storm was also weakening rapidly, but the PRESIDENT JEFFERSON measured 26-ft swells as the LOW passed southeast of her. The CHEVRON MISSISSIPPI was the last to feel the rath of 45-kn winds and 15-ft seas as the storm moved ashore south of Sitka.

An inverted trough was over the Yellow Sea on the 25th. On the 26th a LOW with frontogenesis formed south of Kyushu. The LOW was 992 mb near 34°N, 149°W, on the 27th. At 0000 the MICHIGAN was due north of the storm with 45-kn gales. The PRESIDENT MADISON was farther north at 1200 and measured 54-kn winds and 25-ft seas. The LOW was moving east-northeastward and the higher winds were north of the center rather than south as is more usual. On the 28th the SEATRAIN VALLEY FORGE at 37°N, 149°E, estimated 52-kn easterly winds with 13-ft seas and 36-ft swells. She was paralleling the storm's track and still had 50-kn winds and 13-ft seas on the 29th, but the swells had decreased to 20 ft. The storm was being held south by a large HIGH centered near Mys Lopatka, and the LOW dissipated on the 29th and another formed off Hokkaido and moved up the west side of the HIGH.

Tropical Cyclones, Western Pacific--Typhoon Kim was first detected on the 6th about 500 mi east-southeast of Guam. Two days later she moved across Guam as a tropical storm. It was about this time that Kim first reached typhoon strength. She continued to intensify on her west-northwestward trek. Kim crossed the 15th parallel late on the 9th near 136°E. However, she reversed her path and headed toward the west-southwest and then westward. Winds near her center were now estimated at up to 120 kn. Kim was fast becoming a threat to Luzon. Late on the 13th she carried her roaring winds and torrential rains across Luzon Bay and inland over southern Luzon. Early on the 14th she passed north of Manila and out into the South China Sea. Kim dropped below typhoon strength later in the day. She then swung northward and on the 16th recurved eastward through the Luzon Strait as a depression.

Kim brought death and destruction to the northern Philippines. The typhoon affected some 10,834 Philippine families of which 3,500 were evacuated and given temporary shelter. A total of 5,035 residential buildings were totally damaged, and an estimated 3,726 were partially damaged. Conservative estimates of property and crop damage were put at $26 million. An estimated 47 people died, not including the victims of the hotel fire in Manila. Most were drowned in swollen rivers or struck by falling trees. Two small Philippine freighters and the Indonesian freighter DAYAKA TIGA (3,223 tons) were driven aground by the storm.

The worst typhoon-related disaster occurred in the seven-story Hotel Filipinas in Manila. A fire, presumed to have been started by a candle in the powerless hotel, was fanned by winds from the typhoon and swept through the seaside hotel. Some 44 people were killed, mostly foreign tourists. Firemen battling the blaze saw water from their hoses blown back in their faces by the force of Kim's winds. In other areas some 7,000 families had to flee their flooded homes, and the death toll is at least 19.

Toward the end of the month typhoon Lucy was born among the Caroline Islands. She started just west of Ponape on the 28th. As a depression, she traveled westward through the southern part of the chain. By the time she reached Yap Island on December 1, Lucy was a tropical storm. Her course had shifted toward the west-northwest. Lucy blossomed on the 3d (fig. 86), and she reached typhoon strength early that day. Before the day was over, 120-kn winds were roaring around her center, which was approaching the 15th parallel near 128°E. She was recurving before reaching the Philippines. Winds near her center

remained at 100 kn or more into the 5th, while gales extended 200 to 300 mi from her eye. Even when she began to weaken, Lucy remained potent. On the 6th the ATKM some 400 mi to the southwest of her center encountered 55-kn winds. By this time Lucy was heading due eastward. She continued to weaken as she crossed the 150th meridian near 22°N late on the 7th.

Casualties--The 14,000-ton American cargo vessel MAINE lost containers overboard in heavy weather on a voyage for Los Angeles. The British-registered SILVERDON (22,906 tons) arrived Chiba with heavy weather damage.

SMOOTH LOG, DECEMBER 1977--The North Pacific had the usual density of storm tracks this month. They did not follow the climatological paths very well. The usual track from northern Honshu did not curve northward as quickly as usual; therefore, the path was over the central rather than the western Bering Sea. A less dense track east of the Japanese islands curved northward to join the Bering Sea track. Another track originated near the Date Line between latitudes 35° and 40°N and headed toward the Queen Charlotte Islands. Several storms formed off the coast of California, and three of them reached the coast.

The Aleutian Low was split into two centers as climatology indicates, but the primary centers were reversed, and they were not as deep as their counterparts. The primary center was 1003 mb near 51°N, 166°E, about 400 mi east of Mys Lopatka. The other center at 1007 mb was about 600 mi west of Seattle. A strong high-pressure center (1025 mb) was near Great Slave Lake in Canada. The Pacific High, which normally has a thin east-west configuration, was even more so this month. Its central pressure was slightly weaker, so the north-south gradient was much less than normal.

Surprisingly, the major anomaly center was plus 10 mb over western Alaska. Its pattern stretched into northwestern Canada, where there was another plus 8-mb center. The largest negative center was 6 mb about midway between Hawaii and Seattle.

The upper air pattern was more organized than the surface. The height centers were less than their climatic counterparts with a weaker gradient and, therefore, winds. One significant difference from the climatic pattern was a pronounced ridge on the west coast of Alaska.

The last tropical cyclone of the season, typhoon Mary, developed late in the month and lasted into the New Year.

Extratropical Cyclones--This LOW actually formed in late November but did appear to be significant. However, on December 1 the WEST OCEAN was over 400 mi north of the center with heavy rain, 50-kn winds, and 30-ft swells. Twelve hours later the center had jumped to 43°N, 154°W, at 987 mb, and the WEST OCEAN now reported 33-ft seas and 39-ft swells with 60-kn winds. On the 2d two ships reported 23-ft waves. By the 3d the storm was over Queen Charlotte Sound and crossing the mountains.

This LOW originated off Tokyo on the 1st. By 1200 on the 2d it was a large 986-mb circular storm. The SEA-LAND COMMERCE was caught near 43°N, 156°E, with wretching 70-kn winds and 33-ft seas and swells. Two other ships south and east of the center battled 33-ft swells.

As the storm moved northeastward, it was 964 mb near 46°N, 160°E, at 1200 on the 3d. Four ships had winds over 50 kn. One ship 700 mi to the south bounced on 32-ft swells. There was no let up until midday on the 4th, when a LOW broke off the east side of the circulation, and the main storm turned northwestward. Prior to this the UNIQUE FORTUNE (38°N, 153°E) had only 40-kn winds, but the swells, which were the only waves reported, were 36 ft. The LONG BEACH and SEALAND FINANCE had 33- and 30-ft waves. The storm moved over the Sea of Okhotsk, where it remained stationary for over 60 hr.

This was the LOW that broke away from the one above. At 0000 on the 6th, it was 986 mb near 41°N, 173°W. The PANASIA was 400 mi northwest of the center with 20-ft seas and 32-ft swells. On the 0000 chart of the 7th the LOW had split into three centers. The FEDSTEEL was north of the centers (49°N, 156°W) with 60-kn winds and 15-ft waves, which increased to 30 ft 6 hr later. On the 8th another new center appeared 6° latitude north of the other centers and moved westward. A 1054-mb HIGH was over the Yukon Territory and this tightened the gradient between the two with increased windspeeds. A SHIP reported 55-kn winds and 33-ft swells plus heavy rain. South of the center the highest wave report was 30 ft by the QUEENS WAY BRIDGE.

This storm and another LOW moving eastward and to the south were rotating around a center between them. The buoy 46003 (formerly 46017) reported 26-ft waves. The GOLDEN BEAR (48°N, 161°W) was sailing into 54-kn winds while at 54°N, and the PRESIDENT MADISON had 48-kn easterlies, 23-ft seas, and 26-ft swells on her stern. The buoy was still being rocked by 25-ft waves. The western LOW dissipated on the 10th, while the second one continued to the coast of British Columbia where it died.

This storm developed east of northern Honshu on the 8th. On the 9th it was creating gale-force winds. It passed north of the ASIA INDUSTRY on the 10th at 978 mb pounding her with 25-ft waves. The SHIMA MARU was north of the center with 50-kn winds which continued most of the day. The ASIA INDUSTRY was keeping pace with the storm as she was pushed by 60-kn winds and swells of 40 ft. The ARILD MAERSK was not far away at 36°N, 162°E, with 45-kn winds and 41-ft seas. Another ship about 200 mi to the southwest had 33-ft seas. At 1200 on the 11th, the 976-mb storm was near 39°N, 172°E. The SEA-LAND EXCHANGE passed south of the center and found 40-kn winds with 25-ft seas and swells in the southwest quadrant. The FEDSTEEL was now in the vicinity of this storm with 60-kn easterlies on the 12th. The ASIA INDUSTRY also kept up her speed with 50-kn winds on her stern and 40-ft swells. At 0900 the ANCO DUKE was stationary and

riding 30-ft seas.

The main feature of this storm was high waves in the southern sector, where the winds had a long westerly fetch over a period of time. The KOREAN PEARL was along 29°N at 176°E with 65-kn winds. Swells of 25 to 33 ft were numerous as far south as latitude 25°N. Late on the 13th the center disappeared as part of the overall circulation.

The storm that took over the main cyclonic circulation formed on the occlusion of the storm above on the 11th. It moved ahead of the other center, gradually becoming the primary storm. By 1200 on the 14th the 946-mb maelstrom was in the Gulf of Alaska. A ship west of the center had 55-kn northerly winds. Later in the day the SAKHALIN (58°N, 150°W) had 50-kn winds and 33-ft seas. The LOW remained stationary for 12 hr and early on the 15th was 944 mb. The PHILADELPHIA near 55°N, 137°W, had 40-kn winds, 16-ft seas, and 33-ft swells. Storm warnings for strong winds were posted for the Pacific coast from Point Arena, Ca., northward. Gusts of 70 kn were measured along the Oregon coast. A ship 600 mi southwest of the center had 31-ft swells. The winds were blowing at 50 kn or more. On the 16th the storm was weakening rapidly and remained essentially stationary over the upper Gulf of Alaska. It disappeared on the 19th.

This writeup describes a combination of several LOWs, some of which were quite short-lived. A large dumbbell-shaped HIGH stretched east to west from the Japanese coast. It slowly drifted eastward. On the 16th a LOW moved northeastward out of the Sea of Japan. As the southerly flow on the east side pushed against the slow-moving HIGH, the winds picked up to gale force. A Japanese ship was sailing northeastward with 23-ft seas near 38°N, 147°E. On the next chart another ship found 25-ft waves near 39°N, 150°E, and near 34°N, 146°E, the waves were 28 ft all along the front. On the 17th the storm was moving up the Kurile Islands chain.

The 1036-mb HIGH was over the central ocean at 40°N, 175°W, on the 18th. North of the HIGH on the south side of another LOW, there were two ship reports of 20-ft waves. On the north side of another LOW south of the HIGH, a ship had 40-kn winds and 23-ft waves. On the 19th a ship west of St. Paul Island had 20-ft seas. There were four low-pressure centers rotating clockwise around the HIGH on the 20th. The southern one was now west of the 1034-mb center, and the PRESIDENT EISENHOWER was between the two near 38°N, 177°W, with 39-ft swells. To the south along a front the ATLANTIC HIGHWAY had taken a wrong turn on the freeway and was involved in 23-ft waves. On the east side of the HIGH there were six high-wave reports between 27° and 45°N between longitude 145° and 150°W. Three of these were for 30-ft swells. On the east side of the LOW the EXXON NEW ORLEANS fought 55-kn winds and 34-ft swells.

On the 21st the northern LOW disappeared over the Chukchi Sea. The two LOWs east and west of the HIGH were increasing in intensity and area, while squeezing the HIGH out of existence. A new center developed in the eastern LOW and moved northward. The ARCO FAIRBANKS measured 60-kn winds and 20-ft waves off Cape Mendocino. The HAWAIIAN LEGISLATOR was sailing toward California near 27°N, 138°W, with 48-ft swells. The next day three ships south and west of the LOW reported 21- to 30-ft waves. The HIGH had now slipped far south to latitude 28°N. On the 23d all the cyclones were losing their energy and of little concern.

As the western LOWs described above chewed away at the HIGH and moved northward, there was an area of flat gradient to the west. On the 22d an incipient LOW was analyzed near 45°N, 158°E. It increased its energy and on the 23d had a broad circulation south of the center. Waves of 20 ft were not uncommon, and one ship had 26-ft swells near the front. On the 24th the LOW absorbed two other centers and was 982 mb near 53°N, 177°E. At 0000 on the 25th the JAPAN RAINBOW was presented with 60-kn winds near 49°N, 164°E. Late that day the LOW disappeared over the Bering Sea as the VAN WARRIOR found 60-kn winds at 39°N, 163°E.

A LOW over Manchuria started moving eastward on the 23d. As it moved over the Kuroshio Current, it gained strength. On Christmas Day two ships had 50-kn winds near 34°N, 149°E. By 1200 on the 26th the 952-mb LOW was near 52.5°N, 167°E. There were many ships reporting winds over 50 kn. The highest wind report was received from the GREEN ECHO near 42°N, 171°E. She measured 75-kn winds with 18-ft waves. The TRIUMPH near 46°N, 157°E, battled 66-kn winds and 33-ft waves. The DAIKEI MARU near 40°N, 173°E, was sailing southward at the point of occlusion into 57-kn southerly winds with 20-ft seas and 49-ft swells. A Japanese ship reported a low pressure of 953 mb almost in the center of the LOW. On the 0000 chart of the 27th the LOW was 946 mb. There were eight reports of winds 50 kn or greater. The highest was 62 kn by the SHINZUI MARU at 47°N, 169°E. There were no wave reports, but 6 hr later the waves were 39 ft. The MONTIGNY had 25-ft seas and 36-ft swells at 53°N, 176°W. At this time the influence of the storm extended from Asia to Bristol Bay and the Bering Strait to 30°N. On the 28th the reported winds were not as high, but there were two reports of 33-ft swells north of the Rat Islands. The Russian cargo vessel KAPITAN MILOVZOROV reported heavy weather damage with loss of containers overboard. On the 29th she reported rolling to 49° with additional containers overboard and the loss of two cargo derricks. It was later determined that 50 40-ft containers were lost. The LOW stalled near 59°N, 173°E, until the 31st. On the 29th a secondary LOW, moving northward on the east side of the primary circulation, passed near St. Paul Island, which had 56-kn winds with gusts to 72 kn.

A short-wave trough developed on the 28th on the west side of the previously described LOW. By 1200 on the 29th, a 998-mb center had formed. The storm moved eastward and was 978 mb near 49°N, 164°E, at 1200 on the 30th. Ostrov Urup measured 45-kn winds. Ships off Hokkaido were reporting 50-kn winds. On the 31st the OJI GLORIA fought 55-kn freezing winds off Mys Lopatka. Later in the day there were waves of 28 ft

reported in the same area. A ship reported seas of 39 ft south of the Near Islands. On January 1 the ship had moved only slightly as the winds increased to 60 kn with 36-ft seas and 39-ft swells. The storm crossed the Date Line very late on the 31st. It was now weakening, and on January 1 another LOW adopted the circulation.

This LOW just barely made the month and year. It was first analyzed northeast of Tokyo on the 1200 chart of the 31st. On New Year's Day a ship near the center had 23-ft swells with a thunderstorm and hail. On the 2d, the LJUTOMER (44°N, 177°E) slightly north and east of the warm front was pounded by 44-ft swells from the southeast. The LOW had turned northward and was 968-mb near 55°N, 173°E. A British ship 650 mi southwest of the center had 50-kn winds and 33-ft waves. In the southeastern quadrant a ship had 46-ft swells near 42°N, 174°W, and another had 49-ft swells near 38°N, 174°E. At 1200 on the 3d, Adak Island measured 50-kn winds with hail showers. A ship west of the island had 26-ft swells. The LOW turned westward late on the 3d, and by the 4th the 26-ft swells had moved 300 mi eastward. The storm was weakening over the Kamchatka Peninsula on the 5th.

Tropical Cyclones--Typhoon Mary, a late-season storm, was detected on the 21st near 10°N, 179°E. She developed as she moved toward the west-northwest. By the 23d she was a typhoon. Winds reached a peak for the next few days. On the 25th the winds blew at 95 kn with gusts estimated at 115 kn. During this time Mary was threatening the atolls of Kwajalein and Eniwetok. There was some evacuation but little reported damage. Mary moved southwestward between the two and then turned westward. By the 27th she had dropped back to tropical-storm strength and began her long journey across the tropical Pacific. Tracking mostly westward, Mary feinted toward Guam on the 29th, moved just north of Yap on the 31st, and finally crashed ashore in the central Philippines on January 2. She dissipated quickly among the islands.

Casualties--The American container vessel PRESIDENT PIERCE (21,475 tons) encountered heavy weather on the 5th between Kobe and Seattle and lost containers overboard. The 35,545-ton Greek PANTELIS A. LEMOS arrived Yokohama on the 8th and reported heavy weather damage. The 16,700-ton Indian ALEXANDRA N. reported heavy weather damage, on the 9th, that occurred earlier and had required temporary repairs at British Columbia. The 28,312-ton Liberian-registered tanker MICHAEL J. GOULANDRIS sustained heavy weather damage from the 10th to the 12th to forecastle, bow plating, and deck fittings.

Severe weather, language problems, and damage to the rescue ship hampered efforts to save the foundering 8,922-ton MALAYSIA PERMAI about 360 mi northwest of San Francisco on the 20th. The 17,807-ton HAWAIIAN MONARCH pulled alongside but could not transfer the crewmembers because of high winds and heavy seas. The ship with a crew of 33 had reported taking on water, but it appeared to be in no danger of sinking.

Figure 49.--The Greek Cypriot freighter SAN GEORGE lies aground at Istanbul after being blown aground by a strong south wind. Wide World Photo.

Principal Tracks of Centers of Cyclones at Sea Level, North Atlantic

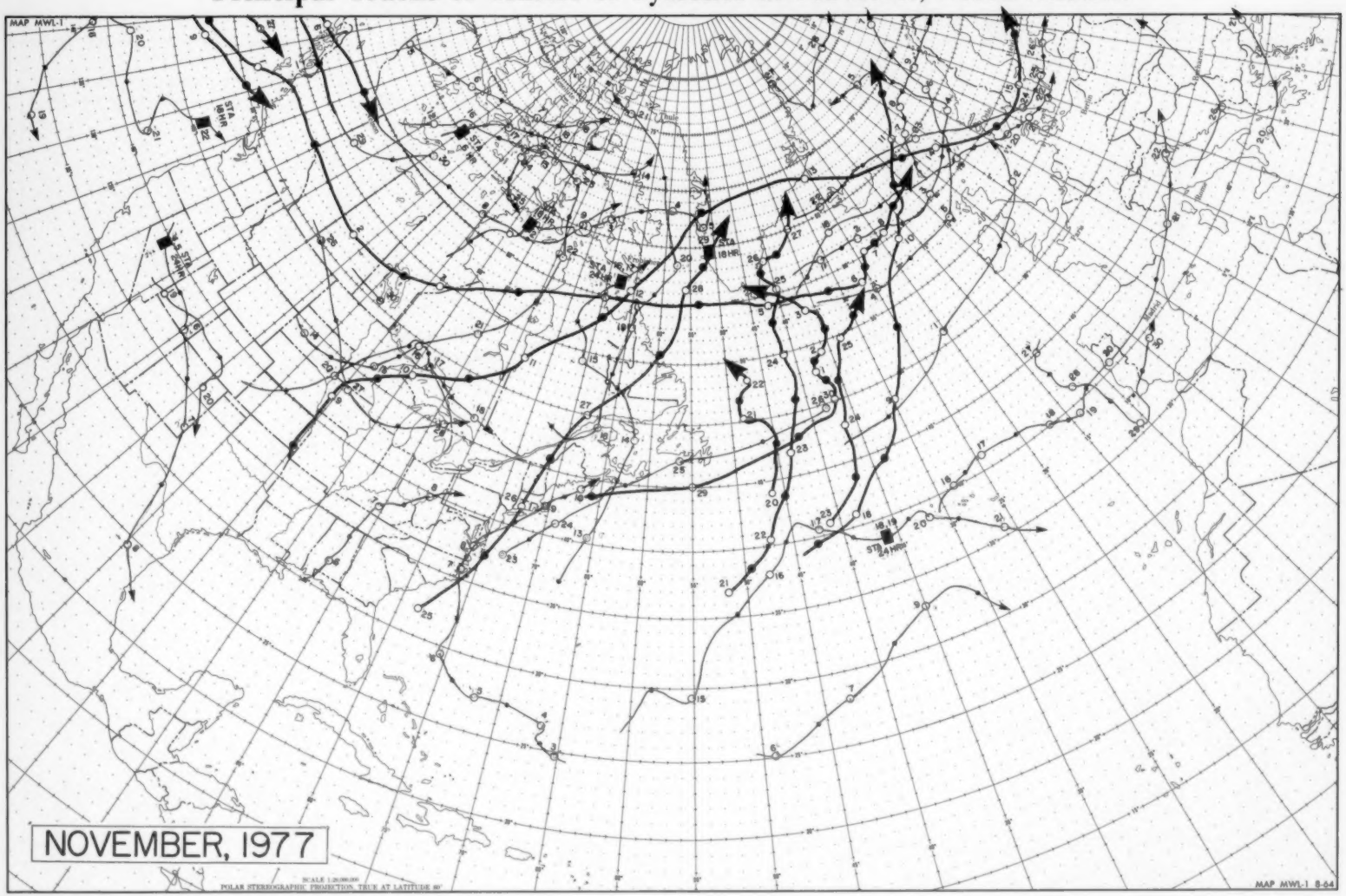


Figure 50.--Open circle indicates 1200 GMT position and closed circle 0000 GMT position. Square indicates stationary center. Cyclone tracks marked with a heavy line are described in the Smooth Log.

Principal Tracks of Centers of Cyclones at Sea Level, North Atlantic

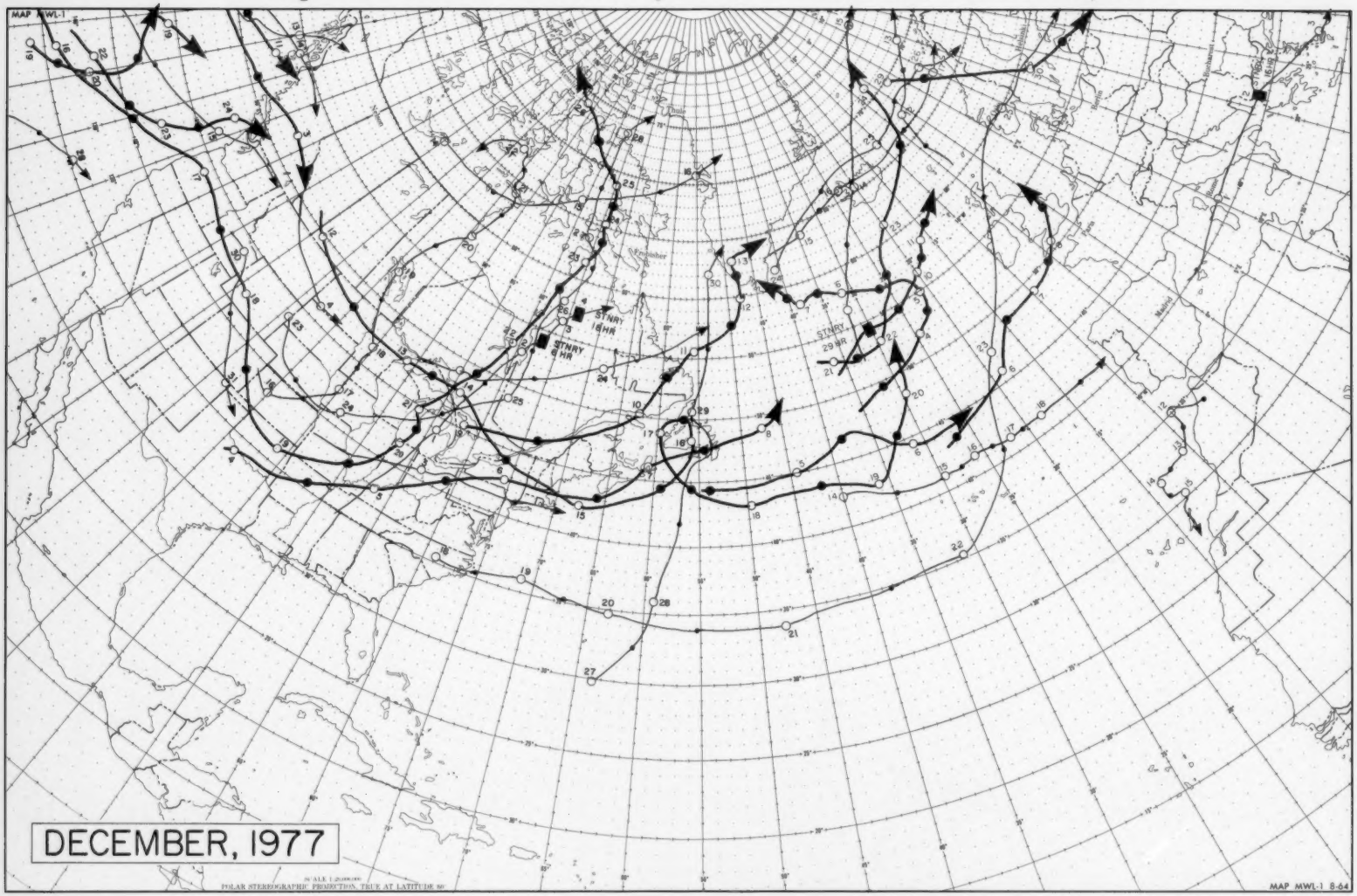


Figure 51.--Open circle indicates 1200 GMT position and closed circle 0000 GMT position. Square indicates stationary center. Cyclone tracks marked with a heavy line are described in the Smooth Log.

Principal Tracks of Centers of Cyclones at Sea Level, North Pacific

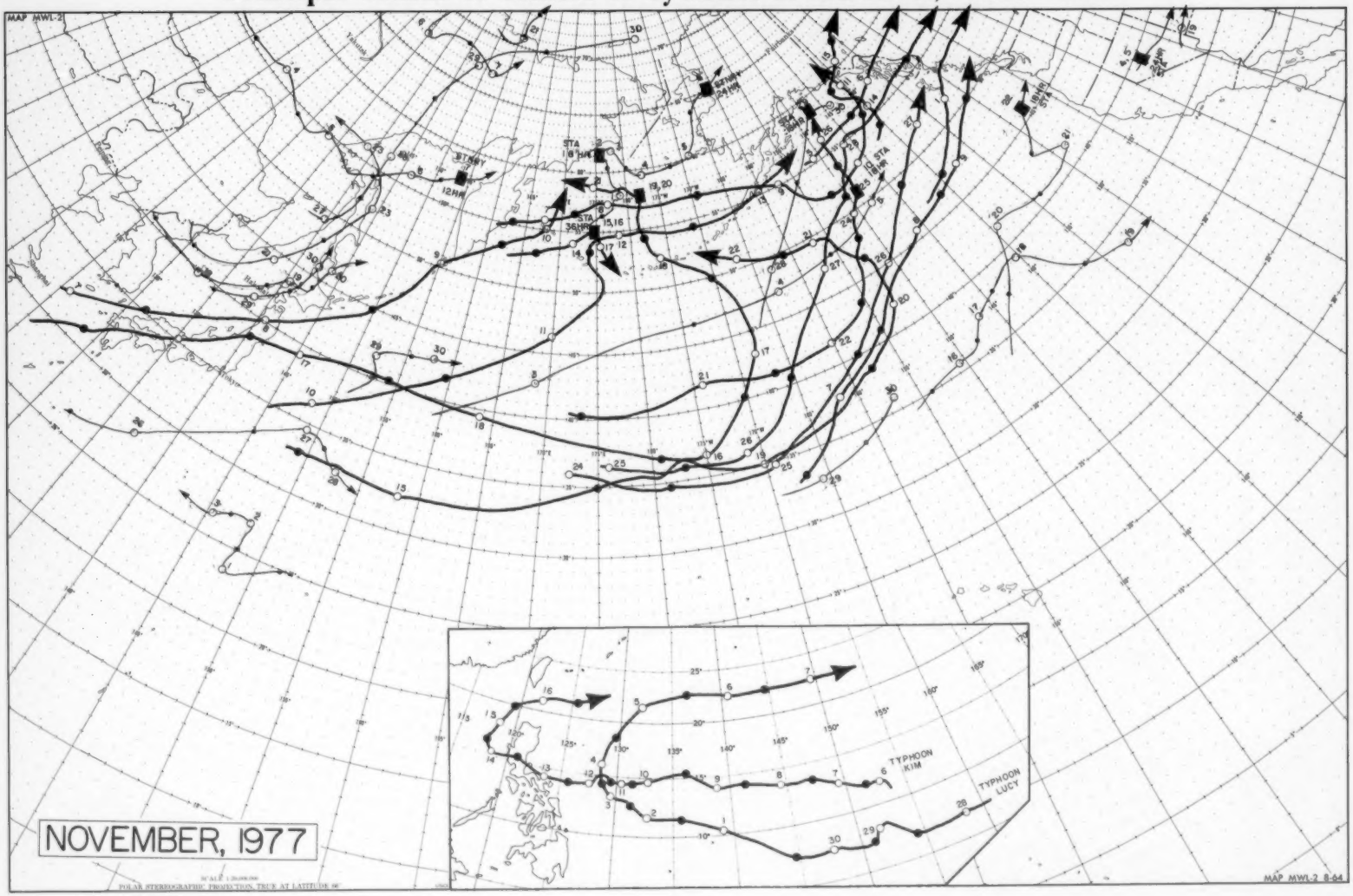


Figure 52.--Open circle indicates 1200 GMT position and closed circle 0000 GMT position. Square indicates stationary center. Cyclone tracks marked with a heavy line are described in the Smooth Log.

Principal Tracks of Centers of Cyclones at Sea Level, North Pacific

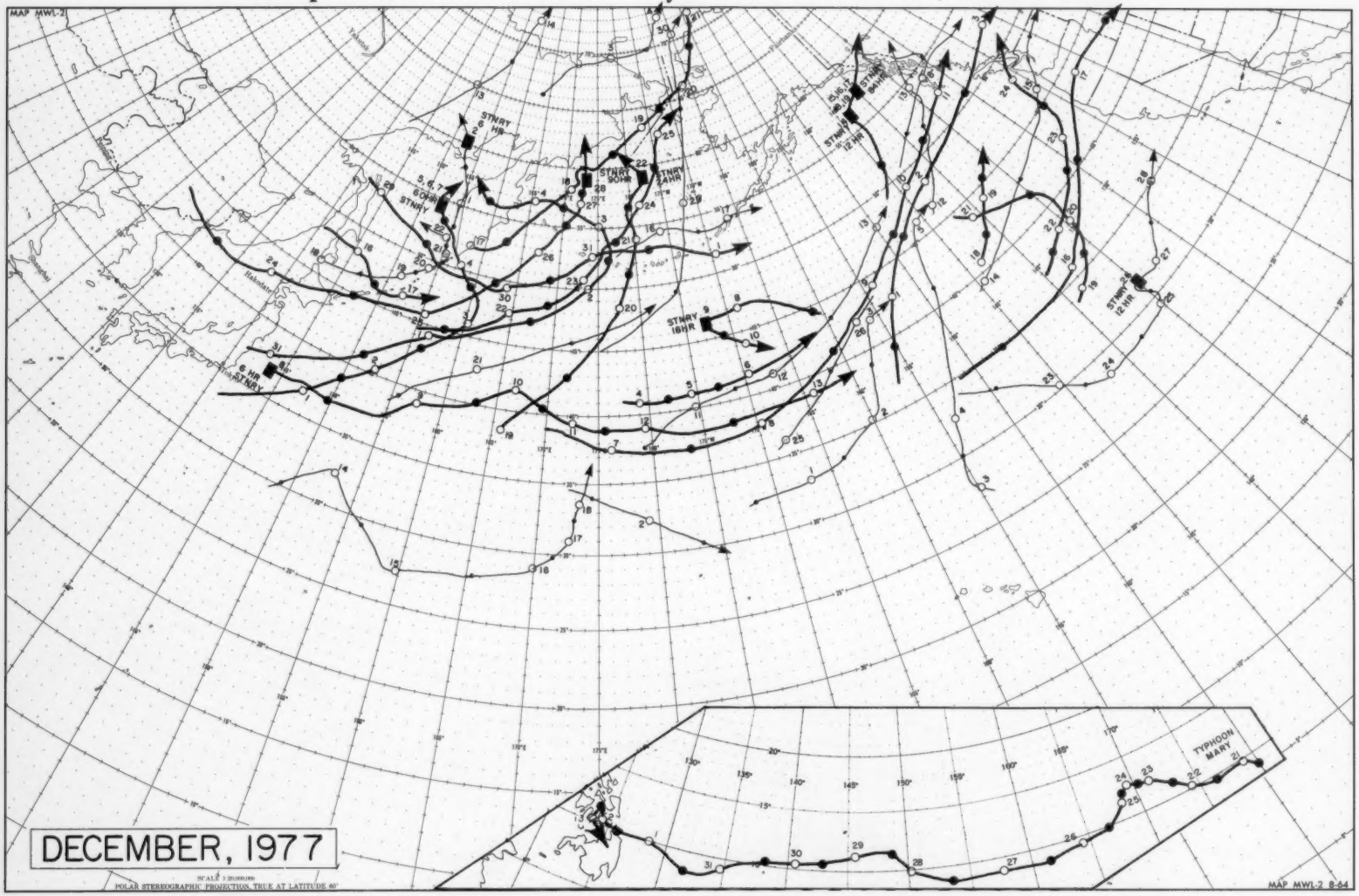


Figure 53. --Open circle indicates 1200 GMT position and closed circle 0000 GMT position. Square indicates stationary center. Cyclone tracks marked with a heavy line are described in the Smooth Log.

Table 18
U.S. Ocean Buoy Climatological Data
November and December 1977

NOVEMBER D A T A S U M M A R Y EB03
AVERAGE LATITUDE 56.0N AVERAGE LONGITUDE 147.5W

MEANS AND EXTREMES

	MIN	(DA HR)	MEAN	MAX	(DA HR)	NO. OF OBS	DAYS WITH DATA
AIR TEMP (DEG C)	-00.8	(16 12)	05.1	08.8	(01 00)	240	30
SEA TEMP (DEG C)	04.8	(30 18)	06.9	08.0	(04 00)	240	30
AIR-SEA TEMP (DEG C)	-06.0	(15 12)	-02.4	00.4	(20 03)	240	30
PRESSURE (MBAR)	0970.5	(15 21)	1004.3	1038.8	(17 21)	240	30

WIND - % FREQUENCIES, MEANS AND EXTREMES

DIR	SPEED (KNOTS) 4-	11-	22-	34-	TOTAL %	MEAN SPEED (KNOTS)	NO. OF OBS: 240
N	.4	2.1	.4		2.9	14.4	MAX WIND
NE	.4	.8	3.3	.4	5.0	25.8	SPEED: 39 KNOTS
E	.4	1.6	5.4	12.1	19.6	34.0	DIRECTION: 280 DEG
SE		.8	4.6	9.4	10.0	20.9	DAY: 07
S	.8	3.3	9.0	.4	9.6	11.9	HOUR: 00
SW	.8	3.8	7.5	1.7	13.8	14.0	
W	1.3	2.9	14.6	13.8	33.3	30.5	
NW		.8	3.8	.8	5.4	18.9	
CALM	.4				.4	0.0	
TOTAL %	4.2	12.1	43.8	37.9	100.0	19.1	

WAVES - % FREQUENCIES, MEAN AND EXTREME (METERS): NO. OF WAVE OBS: 240

HEIGHT (M)	<1	1-1.5	2-2.5	3-3.5	4-5.5	5-7.5	8-9.9	>9.9	MEAN	MAX	(DA HR)
% FREQUENCY		11.7	38.3	30.0	19.2				2.9M	8.0M	(24 06)

NOVEMBER D A T A S U M M A R Y EB04
AVERAGE LATITUDE 28.0N AVERAGE LONGITUDE 080.0W

MEANS AND EXTREMES

	MIN	(DA HR)	MEAN	MAX	(DA HR)	NO. OF OBS	DAYS WITH DATA
AIR TEMP (DEG C)	17.9	(10 21)	23.2	28.2	(08 15)	239	30
SEA TEMP (DEG C)	23.1	(23 09)	24.7	28.4	(03 21)	239	30
AIR-SEA TEMP (DEG C)	-07.7	(10 18)	-01.8	01.1	(28 15)	238	30
PRESSURE (MBAR)	1007.8	(30 21)	1019.7	1027.0	(11 12)	198	28

WIND - % FREQUENCIES, MEANS AND EXTREMES

DIR	SPEED (KNOTS) 4-	11-	22-	34-	TOTAL %	MEAN SPEED (KNOTS)	NO. OF OBS: 240
N		4.6	9.4	3.3	15.3	19.0	MAX WIND
NE	.4	2.9	8.7	1.3	13.3	19.8	SPEED: 28 KNOTS
E	.4	3.8	12.5		16.7	17.2	DIRECTION: 350 DEG
SE	.4	5.8	24.6		30.8	15.5	DAY: 10
S	.8	2.9	3.3		7.1	9.3	HOUR: 09
SW	1.3	1.7	1.7		4.6	7.6	
W	.4	2.5	5.4		8.8	11.7	
NW	1.3	3.3	3.3	1.3	9.0	12.3	
CALM					.8		
TOTAL %	5.0	28.3	62.9	5.0	100.0	12.7	

WAVES - % FREQUENCIES, MEAN AND EXTREME (METERS): NO. OF WAVE OBS: 237

HEIGHT (M)	<1	1-1.5	2-2.5	3-3.5	4-5.5	5-7.5	8-9.9	>9.9	MEAN	MAX	(DA HR)
% FREQUENCY	10.9	67.1	16.9	3.4	2.1				1.0M	4.9M	(10 21)

NOVEMBER D A T A S U M M A R Y EB07
AVERAGE LATITUDE 38.0N AVERAGE LONGITUDE 070.0W

MEANS AND EXTREMES

	MIN	(DA HR)	MEAN	MAX	(DA HR)	NO. OF OBS	DAYS WITH DATA
AIR TEMP (DEG C)	04.1	(27 06)	15.1	21.6	(11 09)	240	30
SEA TEMP (DEG C)	16.2	(30 21)	18.0	21.4	(11 18)	240	30
AIR-SEA TEMP (DEG C)	-14.0	(13 21)	-03.7	01.4	(11 09)	240	30
PRESSURE (MBAR)	0993.2	(26 12)	1021.1	1039.2	(29 15)	240	30

WIND - % FREQUENCIES, MEANS AND EXTREMES

DIR	SPEED (KNOTS) 4-	11-	22-	34-	TOTAL %	MEAN SPEED (KNOTS)	NO. OF OBS: 240
N		.8	4.6	.8	6.3	16.0	MAX WIND
NE		.4	5.0		5.4	14.7	SPEED: 38 KNOTS
E		3.8	13.3	0.6	17.8	18.1	DIRECTION: 280 DEG
SE		3.8	5.8	.4	10.0	11.7	DAY: 27
S		2.5	3.8	2.5	8.8	13.0	HOUR: 12
SW	.4	1.3	5.0	1.7	8.3	16.0	
W	.4	2.1	10.0	9.2	1.7	23.3	20.4
NW			3.8	5.0		8.8	20.1
CALM	.4					.4	0.0
TOTAL %	1.3	14.2	53.8	28.3	2.5	100.0	17.8

WAVES - % FREQUENCIES, MEAN AND EXTREME (METERS): NO. OF WAVE OBS: 197

HEIGHT (M)	<1	1-1.5	2-2.5	3-3.5	4-5.5	5-7.5	8-9.9	>9.9	MEAN	MAX	(DA HR)
% FREQUENCY		25.4	44.7	21.8	6.6	1.5			2.4M	6.5M	(27 12)

NOVEMBER D A T A S U M M A R Y EB10
AVERAGE LATITUDE 32.3N AVERAGE LONGITUDE 075.3W

MEANS AND EXTREMES

	MIN	(DA HR)	MEAN	MAX	(DA HR)	NO. OF OBS	DAYS WITH DATA
AIR TEMP (DEG C)	10.3	(27 06)	20.2	25.2	(09 18)	240	30
SEA TEMP (DEG C)	23.6	(20 09)	23.9	24.9	(09 21)	240	30
AIR-SEA TEMP (DEG C)	-12.4	(27 06)	-03.6	00.5	(17 21)	240	30
PRESSURE (MBAR)	1001.4	(26 09)	1019.6	1030.9	(29 15)	240	30

WIND - % FREQUENCIES, MEANS AND EXTREMES

DIR	SPEED (KNOTS) 4-	11-	22-	34-	TOTAL %	MEAN SPEED (KNOTS)	NO. OF OBS: 240
N	.8	2.9	6.7	1.3	11.7	13.5	MAX WIND
NE	1.3	1.7	4.6		7.5	10.4	SPEED: 36 KNOTS
E	1.7	3.8	16.3	1.3	22.9	14.2	DIRECTION: 280 DEG
SE	.8	3.8	9.2		13.8	11.3	DAY: 27
S	2.1	4.2	13.3	1.3	20.8	12.7	HOUR: 00
SW	1.3	.4	5.0	1.3	7.9	14.5	
W	.4	.8	3.3	1.3	1.3	6.8	18.7
NW		.8	.8	3.3	3.8	7.0	18.4
CALM							
TOTAL %	8.8	21.3	58.8	9.2	1.3	100.0	13.6

WAVES - % FREQUENCIES, MEAN AND EXTREME (METERS): NO. OF WAVE OBS: 239

HEIGHT (M)	<1	1-1.5	2-2.5	3-3.5	4-5.5	5-7.5	8-9.9	>9.9	MEAN	MAX	(DA HR)
% FREQUENCY		2.9	59.6	25.9	10.5	.8			1.8M	4.0M	(27 00)

NOVEMBER D A T A S U M M A R Y EB18
AVERAGE LATITUDE 42.5N AVERAGE LONGITUDE 130.0W

MEANS AND EXTREMES

	MIN	(DA HR)	MEAN	MAX	(DA HR)	NO. OF OBS	DAYS WITH DATA
AIR TEMP (DEG C)	07.8	(20 06)	12.8	18.5	(01 18)	240	30
PRESSURE (MBAR)	0997.4	(04 12)	1018.9	1034.8	(07 18)	240	30

WIND - % FREQUENCIES, MEANS AND EXTREMES

DIR	SPEED (KNOTS) 4-	11-	22-	34-	TOTAL %	MEAN SPEED (KNOTS)	NO. OF OBS: 240
N		1.3	11.3	.8	13.3	16.5	MAX WIND
NE		.8	2.9	.4	4.2	13.7	SPEED: 35 KNOTS
E	.8	.8	2.9	.4	5.0	11.3	DIRECTION: 300 DEG
SE	.8	.4	1.3	.4	2.9	10.9	DAY: 05
S	.4	3.3	5.4	.4	9.2	10.8	HOUR: 03
SW	.4	1.7	14.2	8.8	25.0	19.2	
W		3.8	14.2	5.8	.8	24.6	18.7
NW		.8	5.4	2.9	.4	11.3	18.2
CALM							
TOTAL %	2.9	13.3	66.7	29.8	1.7	100.0	17.9

WAVES - % FREQUENCIES, MEAN AND EXTREME (METERS): NO. OF WAVE OBS: 240

HEIGHT (M)	<1	1-1.5	2-2.5	3-3.5	4-5.5	5-7.5	8-9.9	>9.9	MEAN	MAX	(DA HR)
% FREQUENCY			4.6	37.5	34.6	38.8	2.9		3.1M	7.0M	(05 03)

DECEMBER D A T A S U M M A R Y EB03
AVERAGE LATITUDE 56.0N AVERAGE LONGITUDE 147.0W

MEANS AND EXTREMES

	MIN	(DA HR)	MEAN	MAX	(DA HR)	NO. OF OBS	DAYS WITH DATA
AIR TEMP (DEG C)	-00.5	(12 09)	01.2	04.1	(28 12)	248	31
SEA TEMP (DEG C)	03.2	(31 21)	03.7	04.8	(01 12)	248	31
AIR-SEA TEMP (DEG C)	-04.1	(12 09)	-02.5	00.8	(28 12)	248	31
PRESSURE (MBAR)	0965.6	(14 21)	1008.8	1028.7	(08 03)	248	31

WIND - % FREQUENCIES, MEANS AND EXTREMES

DIR	SPEED (KNOTS) 4-	11-	22-	34-	TOTAL %	MEAN SPEED (KNOTS)	NO. OF OBS: 248
N	.4	4.0	7.7	3.6	15.7	15.0	MAX WIND
NE	.4	.8	2.0	3.2	6.5	20.3	SPEED: 33 KNOTS
E		1.6	.8	5.6	8.1	22.0	DIRECTION: 070 DEG
SE	1.2	.4	2.8	.4	4.8	11.5	DAY: 08
S	.4	3.2	8.1	3.2	14.9	14.7	HOUR: 06
SW		1.2	3.6	.4	5.2	13.0	
W		4.0	4.8	4.4	13.3	19.7	
NW	1.2	4.0	10.1	6.5	20.8	17.6	
CALM	1.6				1.6	0.0	
TOTAL %	5.2	19.4	46.0	29.4	100.0	16.7	

WAVES - % FREQUENCIES, MEAN AND EXTREME (METERS): NO. OF WAVE OBS: 247

HEIGHT (M)	<1	1-1.5	2-2.5	3-3.5	4-5.5	6-7.5	8-9.9	>9.9	MEAN	MAX	(DA HR)
% FREQUENCY		12.1	48.0	20.6	13.0				2.6M	4.5M	(19 00)

% OF OBS WITH POTENTIAL SUPERSTRUCTURE ICING: MODERATE: 9.2% SEVERE: NONE 9095: 206

DECEMBER D A T A S U M M A R Y EB04
AVERAGE LATITUDE 28.0N AVERAGE LONGITUDE 080.0W

MEANS AND EXTREMES

	MIN	(DA HR)	MEAN	MAX	(DA HR)	NO. OF OBS	DAYS WITH DATA
AIR TEMP (DEG C)	14.2	(22 15)	20.5	26.2	(04 21)	211	29
SEA TEMP (DEG C)	21.8	(28 09)	23.1	25.8	(04 21)	212	28
AIR-SEA TEMP (DEG C)	-08.2	(22 15)	-02.6	00.8	(09 21)	211	29
PRESSURE (MBAR)	1009.3	(01 00)	1018.3	1030.4	(22 15)	198	28

WIND - % FREQUENCIES, MEANS AND EXTREMES

DIR	SPEED (KNOTS) 4-	11-	22-	34-	TOTAL %	MEAN SPEED (KNOTS)	NO. OF OBS: 212
N		1.9	7.1	5.7	14.6	18.6	MAX WIND
NE		5.2	12.3	3.8	21.2	16.4	SPEED: 28 KNOTS
E	.5	2.4	14.6		17.5	12.8	DIRECTION: 300 DEG
SE	.5	3.3	12.3		16.0	12.3	DAY: 07
S		3.8	14.2		17.8	12.2	HOUR: 21
SW		2.4	7.7		10.1	12.7	
W		1.4	.9		2.4	9.4	
NW		.5	2.8	2.4	5.7	19.3	
CALM							
TOTAL %	.9	20.8	66.5	11.8	100.0	14.1	

WAVES - % FREQUENCIES, MEAN AND EXTREME (METERS): NO. OF WAVE OBS: 207

HEIGHT (M)	<1	1-1.5	2-2.5	3-3.5	4-5.5	6-7.5	8-9.9	>9.9	MEAN	MAX	(DA HR)
% FREQUENCY	15.0	58.5	19.0	6.5	1.0				1.0M	5.0M	(22 03)

DECEMBER D A T A S U M M A R Y EB07
AVERAGE LATITUDE 39.0N AVERAGE LONGITUDE 070.0W

MEANS AND EXTREMES

	MIN	(DA HR)	MEAN	MAX	(DA HR)	NO. OF OBS	DAYS WITH DATA
AIR TEMP (DEG C)	09.8	(22 00)	18.4	23.6	(22 00)	248	31
SEA TEMP (DEG C)	08.2	(31 21)	19.3	23.0	(21 00)	248	31
AIR-SEA TEMP (DEG C)	-08.7	(18 03)	01.1	04.0	(31 12)	248	31
PRESSURE (MBAR)	0984.5	(05 18)	1015.8	1034.5	(13 15)	248	31

WIND - % FREQUENCIES, MEANS AND EXTREMES

DIR	SPEED (KNOTS) 4-	11-	22-	34-	TOTAL %	MEAN SPEED (KNOTS)	NO. OF OBS: 248
N		.8	2.8	.8	4.4	19.8	MAX WIND
NE			3.8	1.6	5.6	20.1	SPEED: 40 KNOTS
E		.4	2.0	2.8	6.0	23.0	DIRECTION: 290 DEG
SE	.8	.4	2.0	.8	4.0	19.0	DAY: 12
S	.4	2.0	4.4	5.6	12.5	19.4	HOUR: 12
SW		1.2	6.5	3.2	10.9	17.8	
W		1.2	15.7	8.9	4.8	27.8	21.4
NW	.4	3.2	12.9	9.3		25.8	19.1
CALM							
TOTAL %	1.6	9.3	51.2	30.3	7.7	100.0	20.2

WAVES - % FREQUENCIES, MEAN AND EXTREME (METERS): NO. OF WAVE OBS: 175

HEIGHT (M)	<1	1-1.5	2-2.5	3-3.5	4-5.5	6-7.5	8-9.5	>9.5	MEAN	MAX	(DA HR)
% FREQUENCY		12.6	41.1	24.6	16.6	5.1			3.0M	7.0M	(20 03)

% OF OBS WITH POTENTIAL SUPERSTRUCTURE ICING: MODERATE: 1.2% SEVERE: NONE 9095: 248

DECEMBER D A T A S U M M A R Y EB10
AVERAGE LATITUDE 32.3N AVERAGE LONGITUDE 075.3W

MEANS AND EXTREMES

	MIN	(DA HR)	MEAN	MAX	(DA HR)	NO. OF OBS	DAYS WITH DATA
AIR TEMP (DEG C)	08.2	(27 00)	17.3	23.8	(06 12)	247	31
SEA TEMP (DEG C)	21.3	(30 15)	22.0	24.0	(06 18)	248	31
AIR-SEA TEMP (DEG C)	-12.7	(26 21)	-05.4	00.5	(15 06)	247	31
PRESSURE (MBAR)	1001.2	(05 12)	1018.8	1032.3	(13 15)	248	31

WIND - % FREQUENCIES, MEANS AND EXTREMES

DIR	SPEED (KNOTS) 4-	11-	22-	34-	TOTAL %	MEAN SPEED (KNOTS)	NO. OF OBS: 248
N	.4	4.4	7.7	1.2	13.7	15.2	MAX WIND
NE	.8	.8	4.0		5.6	9.5	SPEED: 35 KNOTS
E		.8	6.0		6.9	16.0	DIRECTION: 200 DEG
SE		1.6	7.7	.4	9.7	14.4	DAY: 06
S		3.2	5.2	7.3	1.2	16.9	20.6
SW		.8	3.6	6.9		10.9	21.3
W		2.4	8.9	.8		12.9	18.8
NW	.4	2.0	11.3	7.3		21.0	18.8
CALM	.4					.4	0.0
TOTAL %	2.0	15.1	60.0	20.9	2.0	100.0	17.7

WAVES - % FREQUENCIES, MEAN AND EXTREME (METERS): NO. OF WAVE OBS: 248

HEIGHT (M)	<1	1-1.5	2-2.5	3-3.5	4-5.5	6-7.5	8-9.5	>9.5	MEAN	MAX	(DA HR)
% FREQUENCY	4.0	52.8	23.4	11.3	8.5				1.8M	5.5M	(20 06)

DECEMBER D A T A S U M M A R Y EB18
AVERAGE LATITUDE 42.5N AVERAGE LONGITUDE 130.0W

MEANS AND EXTREMES

	MIN	(DA HR)	MEAN	MAX	(DA HR)	NO. OF OBS	DAYS WITH DATA
AIR TEMP (DEG C)	08.2	(18 06)	11.8	15.4	(13 12)	245	31
PRESSURE (MBAR)	0988.0	(23 03)	1012.2	1028.2	(01 00)	245	31

WIND - % FREQUENCIES, MEANS AND EXTREMES

DIR	SPEED (KNOTS) 4-	11-	22-	34-	TOTAL %	MEAN SPEED (KNOTS)	NO. OF OBS: 245
N	.4	3.7	2.4		6.5	9.8	MAX WIND
NE	.4	2.9	4.1	2.0	9.4	14.7	SPEED: 48 KNOTS
E	.4	6.1	2.8	.4	9.8	10.1	DIRECTION: 280 DEG
SE		1.6	2.0	2.4	5.7	8.8	26.0
S		.4	5.3	6.9		11.0	16.7
SW	.8	2.0	9.2	9.4	.4	20.8	19.0
W	.4	3.7	10.2	4.5	.4	20.0	16.7
NW	.4	4.1	8.5	.8		13.9	13.0
CALM							
TOTAL %	2.9	24.5	45.3	26.1	1.2	100.0	17.0

WAVES - % FREQUENCIES, MEAN AND EXTREME (METERS): NO. OF WAVE OBS: 244

HEIGHT (M)	<1	1-1.5	2-2.5	3-3.5	4-5.5	6-7.5	8-9.5	>9.5	MEAN	MAX	(DA HR)
% FREQUENCY		17.6	38.5	20.9	16.8	7.8	.4		3.0M	8.0M	(15 12)

NOVEMBER D A T A S U M M A R Y EB17

AVERAGE LATITUDE 53.0N AVERAGE LONGITUDE 156.0W

MEANS AND EXTREMES

	MIN	(DA HR)	MEAN	MAX	(DA HR)	NO. OF OBS	DAYS WITH DATA
AIR TEMP (DEG C)	-01.0	(30 18)	03.5	09.0	(19 15)	239	30
SEA TEMP (DEG C)	04.2	(30 21)	05.1	06.3	(04 00)	240	30
AIR-SEA TEMP (DEG C)	-05.2	(30 18)	-01.7	01.1	(19 09)	239	30
PRESSURE (MBAR)	0971.6	(13 12)	1001.7	1029.8	(16 21)	240	30

WIND - % FREQUENCIES, MEANS AND EXTREMES

SPEED (KNOTS) DIR	0	4	11	22	34	>47	MEAN TOTAL %	MEAN SPEED (KNOTS)
N		.4	2.8	1.7			5.0	18.2
NE		.4	1.3	2.5	4.6		8.8	31.3
E		.4	1.7	2.1	3.3		7.5	27.7
SE		1.7	2.5	3.8	1.3		9.2	25.2
S			.8	2.5	4.2	.4	7.9	29.2
SW		.4	2.9	5.0	.8	.4	9.6	29.9
W		.8	5.0	19.3	12.5	.4	37.1	38.5
NW			1.3	6.3	4.6		12.1	30.5
CALM	1.3	.4					1.8	00.0
TOTAL	1.3	2.1	12.8	40.4	32.1	12.5	100.0	20.8

NO. OF OBS: 240

MAX WIND
SPEED: 42 KNOTS
DIRECTION: 050 DEG
DAY: 25
HOUR: 15

WAVES - % FREQUENCIES, MEAN AND EXTREME (METERS) NO. OF WAVE OBS: 240

HEIGHT (M)	<1	1-1.5	2-2.5	3-3.5	4-5.5	6-7.5	8-9.5	>9.5	MEAN	MAX (DA HR)
% FREQUENCY		11.3	31.7	23.8	20.0	12.1	1.3		3.6M	8.0M (24 05)

NOVEMBER D A T A S U M M A R Y EB20

AVERAGE LATITUDE 41.1N AVERAGE LONGITUDE 137.8W

MEANS AND EXTREMES

	MIN	(DA HR)	MEAN	MAX	(DA HR)	NO. OF OBS	DAYS WITH DATA
AIR TEMP (DEG C)	09.3	(11 03)	13.7	17.1	(01 12)	240	30
PRESSURE (MBAR)	0997.8	(21 09)	1018.8	1039.7	(07 18)	240	30

WIND - % FREQUENCIES, MEANS AND EXTREMES

SPEED (KNOTS) DIR	0	4	11	22	34	>47	MEAN TOTAL %	MEAN SPEED (KNOTS)
N				1.7			1.7	12.5
NE				2.5	.4		2.9	15.3
E			.4	2.9	4.6	2.1	10.0	24.1
SE		1.7	5.0	2.1			8.8	18.1
S		.8	6.3	3.3	.8		11.3	18.8
SW		1.3	13.8	13.3	.8		29.2	21.1
W		.4	10.4	11.3	1.7		23.8	22.4
NW		.8	3.3	4.2			10.0	21.0
CALM	7.9						7.9	00.0
TOTAL	7.9	4.6	46.7	40.0	9.4	2.1	100.0	20.4

NO. OF OBS: 240

MAX WIND
SPEED: 37 KNOTS
DIRECTION: 100 DEG
DAY: 19
HOUR: 00

WAVES - % FREQUENCIES, MEAN AND EXTREME (METERS) NO. OF WAVE OBS: 240

HEIGHT (M)	<1	1-1.5	2-2.5	3-3.5	4-5.5	6-7.5	8-9.5	>9.5	MEAN	MAX (DA HR)
% FREQUENCY		9.0	32.5	35.8	24.6	2.1			3.2M	7.0M (12 19)

NOVEMBER D A T A S U M M A R Y EB21

AVERAGE LATITUDE 48.0N AVERAGE LONGITUDE 131.0W

MEANS AND EXTREMES

	MIN	(DA HR)	MEAN	MAX	(DA HR)	NO. OF OBS	DAYS WITH DATA
AIR TEMP (DEG C)	04.5	(20 18)	10.3	14.6	(01 12)	232	30
SEA TEMP (DEG C)	10.7	(26 18)	11.5	13.0	(01 06)	232	30
AIR-SEA TEMP (DEG C)	-08.6	(20 18)	-01.3	02.2	(28 21)	232	30
PRESSURE (MBAR)	0980.9	(04 15)	1015.1	1038.0	(17 09)	232	30

WIND - % FREQUENCIES, MEANS AND EXTREMES

SPEED (KNOTS) DIR	0	4	11	22	34	>47	MEAN TOTAL %	MEAN SPEED (KNOTS)
N		.4	2.2	4.3	5.2		12.1	18.7
NE				1.7			1.7	17.3
E			2.2	2.2	3.4		7.8	19.1
SE		.8	3.0	5.2	3.4		12.3	18.4
S		.4	1.7	3.9	8.1	.9	22.0	20.7
SW		.4	1.7	4.3	11.6	1.3	19.4	22.4
W			.4	10.8	10.3	.9	22.4	21.7
NW		.4	1.3	4.3	4.3		10.3	19.0
CALM	.4						.4	00.0
TOTAL	5.0	6.9	38.9	46.3	5.0		100.0	20.3

NO. OF OBS: 232

MAX WIND
SPEED: 37 KNOTS
DIRECTION: 240 DEG
DAY: 12
HOUR: 21

WAVES - % FREQUENCIES, MEAN AND EXTREME (METERS) NO. OF WAVE OBS: 230

HEIGHT (M)	<1	1-1.5	2-2.5	3-3.5	4-5.5	6-7.5	8-9.5	>9.5	MEAN	MAX (DA HR)
% FREQUENCY		5.7	17.0	43.5	33.0	.9			3.4M	6.5M (14 21)

NOVEMBER D A T A S U M M A R Y EB34

AVERAGE LATITUDE 40.1N AVERAGE LONGITUDE 073.0W

MEANS AND EXTREMES

	MIN	(DA HR)	MEAN	MAX	(DA HR)	NO. OF OBS	DAYS WITH DATA
AIR TEMP (DEG C)	00.9	(27 12)	10.8	19.0	(11 03)	240	30
SEA TEMP (DEG C)	10.0	(22 12)	13.7	19.1	(04 03)	240	30
AIR-SEA TEMP (DEG C)	-12.1	(27 12)	-02.9	02.7	(11 03)	240	30
PRESSURE (MBAR)	0982.0	(28 09)	1020.7	1037.3	(28 15)	240	30

WIND - % FREQUENCIES, MEANS AND EXTREMES

SPEED (KNOTS) DIR	0	4	11	22	34	>47	MEAN TOTAL %	MEAN SPEED (KNOTS)
N			1.7	4.2	2.9		8.8	19.8
NE		.4	3.8	8.8	1.7		14.8	14.0
E			1.3	6.4	.4		8.1	15.0
SE		.4	1.3	6.4	.9		8.9	19.3
S		.4	1.3	8.1	.4		10.2	16.1
SW		.4	5.0	11.0	11.0		27.3	18.5
W			1.3	5.8	3.1		10.2	17.5
NW				3.4	2.2	.9	6.5	16.4
CALM	1.3						1.3	00.0
TOTAL	1.3	10.0	23.1	10.6			100.0	16.0

NO. OF OBS: 236

MAX WIND
SPEED: 31 KNOTS
DIRECTION: 270 DEG
DAY: 27
HOUR: 06

NOVEMBER D A T A S U M M A R Y EB41

AVERAGE LATITUDE 38.7N AVERAGE LONGITUDE 073.8W

MEANS AND EXTREMES

	MIN	(DA HR)	MEAN	MAX	(DA HR)	NO. OF OBS	DAYS WITH DATA
AIR TEMP (DEG C)	01.8	(27 15)	11.7	17.7	(11 03)	240	30
SEA TEMP (DEG C)	10.2	(30 09)	13.2	16.8	(10 03)	240	30
AIR-SEA TEMP (DEG C)	-11.0	(27 15)	-01.4	04.0	(07 18)	240	30
PRESSURE (MBAR)	0984.8	(28 12)	1020.2	1034.8	(29 15)	240	30

WIND - % FREQUENCIES, MEANS AND EXTREMES

SPEED (KNOTS) DIR	0	4	11	22	34	>47	MEAN TOTAL %	MEAN SPEED (KNOTS)
N		.4	2.5	3.4			6.3	11.0
NE		.4	7.1	13.4			21.0	16.8
E		1.7	7.1	8.3	.4		15.5	15.7
SE		.4	4.2	1.3			5.8	10.5
S			1.7	5.0			7.1	14.2
SW		.4	2.5	7.1			10.1	12.9
W		.4	3.8	8.7	3.4		16.4	18.0
NW			3.4	12.2	.8		16.4	15.4
CALM	1.3						1.3	00.0
TOTAL	1.3	3.8	32.4	58.2	4.6		100.0	13.8

NO. OF OBS: 230

MAX WIND
SPEED: 28 KNOTS
DIRECTION: 280 DEG
DAY: 27
HOUR: 08

WAVES - % FREQUENCIES, MEAN AND EXTREME (METERS) NO. OF WAVE OBS: 240

HEIGHT (M)	<1	1-1.5	2-2.5	3-3.5	4-5.5	6-7.5	8-9.5	>9.5	MEAN	MAX (DA HR)
% FREQUENCY	7.1	41.3	33.3	17.9	.4				1.9M	4.0M (09 19)

NOVEMBER D A T A S U M M A R Y EB44

AVERAGE LATITUDE 26.0N AVERAGE LONGITUDE 086.0W

MEANS AND EXTREMES

	MIN	(DA HR)	MEAN	MAX	(DA HR)	NO. OF OBS	DAYS WITH DATA
AIR TEMP (DEG C)	17.4	(11 15)	23.3	28.4	(09 21)	238	30
SEA TEMP (DEG C)	23.7	(20 03)	25.1	25.8	(04 09)	238	30
AIR-SEA TEMP (DEG C)	-08.0	(11 15)	-01.8	03.4	(22 12)	238	30
PRESSURE (MBAR)	1009.7	(03 09)	1018.8	1027.1	(12 15)	238	30

WIND - % FREQUENCIES, MEANS AND EXTREMES

SPEED (KNOTS) DIR	0	4	11	22	34	>47	MEAN TOTAL %	MEAN SPEED (KNOTS)
N		.4	1.7	11.8	.4		14.3	16.7
NE		.8	3.8	2.9			7.6	9.1
E		2.5	5.5	28.1			36.2	11.9
SE			2.9	13.4			16.8	12.3
S		.4	3.4	.8			4.6	9.4
SW		1.3	4.2	4.2			9.7	10.8
W			4.2	3.8			7.6	10.3
NW		1.3	4.6	.8			6.7	7.4
CALM	.8						.8	.0
TOTAL	3.8	8.0	37.7	65.9	.4		100.0	11.4

NO. OF OBS: 232

MAX WIND
SPEED: 22 KNOTS
DIRECTION: 350 DEG
DAY: 10
HOUR: 15

WAVES - % FREQUENCIES, MEAN AND EXTREME (METERS) NO. OF WAVE OBS: 232

HEIGHT (M)	<1	1-1.5	2-2.5	3-3.5	4-5.5	6-7.5	8-9.5	>9.5	MEAN	MAX (DA HR)
% FREQUENCY	15.9	64.7	14.2	4.3	.8				1.4M	4.0M (11 03)

DECEMBER D A T A S U M M A R Y EB17

AVERAGE LATITUDE 52.0N AVERAGE LONGITUDE 156.0W

MEANS AND EXTREMES

	MIN	(DA HR)	MEAN	MAX	(DA HR)	NO. OF OBS	DAYS WITH DATA
AIR TEMP (DEG C)	-04.5	(13 12)	01.6	04.6	(24 18)	248	31
SEA TEMP (DEG C)	03.3	(30 03)	03.7	04.3	(01 09)	248	31
AIR-SEA TEMP (DEG C)	-08.0	(13 12)	-02.2	01.0	(24 18)	248	31
PRESSURE (MBAR)	0977.6	(14 15)	1010.9	1032.2	(04 09)	248	31

WIND - % FREQUENCIES, MEANS AND EXTREMES

SPEED (KNOTS) DIR	0	4	11	22	34	>47	MEAN TOTAL %	MEAN SPEED (KNOTS)
N			2.0	10.1	5.2		17.3	18.0
NE			1.6	4.0	2.0	2.8	11.3	22.5
E			1.6	5.2	2.0	2.8	11.3	23.1
SE			2.4	6.5	.8		9.7	13.6
S			2.8	7.3	.4		10.5	13.8
SW		.4	2.4	4.4			7.3	10.4
W		.4	2.4	10.5	.8		14.1	14.8
NW			.4	7.3	8.3		16.0	21.6
CALM	1.6						1.6	.0
TOTAL	2.4	15.7	54.0	22.2	5.6		100.0	17.5

NO. OF OBS: 248

MAX WIND
SPEED: 36 KNOTS
DIRECTION: 060 DEG
DAY: 09
HOUR: 12

WAVES - % FREQUENCIES, MEAN AND EXTREME (METERS) NO. OF WAVE OBS: 248

HEIGHT (M)	<1	1-1.5	2-2.5	3-3.5	4-5.5	6-7.5	8-9.5	>9.5	MEAN	MAX (DA HR)
% FREQUENCY		8.0	42.7	25.0	18.5	6.9	.8		3.2M	6.0M (09 18)

% OF OBS WITH POTENTIAL SUPERSTRUCTURE ICING MODERATE: 6.0% SEVERE: NONE #OBS: 248

DECEMBER D A T A S U M M A R Y EB20

AVERAGE LATITUDE 41.1N AVERAGE LONGITUDE 137.8W

MEANS AND EXTREMES

	MIN	(DA HR)	MEAN	MAX	(DA HR)	NO. OF OBS	DAYS WITH DATA
AIR TEMP (DEG C)	07.3	(17 09)	13.3	18.1	(12 18)	247	31
PRESSURE (MBAR)	0988.0	(21 00)	1011.8	1028.7	(01 00)	247	31

WIND - % FREQUENCIES, MEANS AND EXTREMES

SPEED (KNOTS) DIR	0	4	11	22	34	>47	MEAN TOTAL %	MEAN SPEED (KNOTS)
N		.4	3.3	.8			4.5	7.8
NE		.4	1.6	4.1	1.2		7.3	15.0
E		.4	2.0	5.7	2.8	.4	11.4	17.3
SE			.8	2.8	.8		4.9	16.2
S		.8	1.2	7.3	5.1		14.4	19.4
SW			1.2	8.5	10.6	.8	21.1	20.8
W			3.7	6.5	8.9	.8	19.8	20.7
NW		.4	3.7	10.2	1.2		15.4	15.0
CALM	1.2						1.2	.0
TOTAL	1.2	2.8	17.5	45.9	31.7	2.0	100.0	18.0

NO. OF OBS: 248

MAX WIND
SPEED: 46 KNOTS
DIRECTION: 280 DEG
DAY: 19
HOUR: 00

WAVES - % FREQUENCIES, MEAN AND EXTREME (METERS) NO. OF WAVE OBS: 247

HEIGHT (M)	<1	1-1.5	2-2.5	3-3.5	4-5.5	6-7.5	8-9.5	>9.5	MEAN	MAX (DA HR)
% FREQUENCY		9.7	38.4	24.7	25.9	3.2			3.1M	7.0M (15 03)

DECEMBER D A T A S U M M A R Y EB21

AVERAGE LATITUDE 48.0N AVERAGE LONGITUDE 131.0W

MEANS AND EXTREMES

	MIN	(DA HR)	MEAN	MAX	(DA HR)	NO. OF OBS	DAYS WITH DATA
AIR TEMP (DEG C)	04.5	(18 09)	09.4	12.5	(10 09)	210	31
SEA TEMP (DEG C)	09.4	(29 12)	10.2	11.0	(02 09)	210	31
AIR-SEA TEMP (DEG C)	-05.4	(15 06)	-00.8	02.5	(21 00)	210	31
PRESSURE (MBAR)	0985.0	(15 06)	1010.2	1028.4	(25 18)	210	31

WIND - % FREQUENCIES, MEANS AND EXTREMES

SPEED (KNOTS) DIR	0	4	11	22	34	>47	MEAN TOTAL %	MEAN SPEED (KNOTS)
N		.4	1.4	4.1			5.6	9.7
NE		1.0	2.3	8.3	1.4		13.7	13.9
E		.9	1.8	4.1	2.3		9.1	15.3
SE			.5	1.4	5.9	2.3	10.0	20.1
S			.5	4.6	3.7		8.7	20.0
SW		.9	1.4	7.8	10.6		20.8	19.7
W			.9	5.0	7.8	.9	14.6	22.2
NW		.9	.5	9.1	8.3	.9	19.3	18.9
CALM	.5						.5	.0
TOTAL	6.4	11.9	44.3	33.3	4.1		100.0	18.6

NO. OF OBS: 210

MAX WIND
SPEED: 48 KNOTS
DIRECTION: 310 DEG
DAY: 19
HOUR: 12

WAVES - % FREQUENCIES, MEAN AND EXTREME (METERS) NO. OF WAVE OBS: 210

HEIGHT (M)	<1	1-1.5	2-2.5	3-3.5	4-5.5	6-7.5	8-9.5	>9.5	MEAN	MAX (DA HR)
% FREQUENCY		13.7	32.4	27.4	21.0	5.5			3.1M	7.0M (21 03)

DECEMBER D A T A S U M M A R Y EB34

AVERAGE LATITUDE 40.1N AVERAGE LONGITUDE 073.0W

MEANS AND EXTREMES

	MIN	(DA HR)	MEAN	MAX	(DA HR)	NO. OF OBS	DAYS WITH DATA
AIR TEMP (DEG C)	-05.8	(11 15)	06.0	15.5	(01 09)	248	31
SEA TEMP (DEG C)	08.8	(31 21)	10.5	12.6	(02 15)	248	31
AIR-SEA TEMP (DEG C)	-18.2	(11 12)	-09.9	02.9	(01 09)	248	31
PRESSURE (MBAR)	0988.5	(08 18)	1017.3	1038.8	(12 12)	248	31

WIND - % FREQUENCIES, MEANS AND EXTREMES

SPEED (KNOTS) DIR	0	4	11	22	34	>47	MEAN TOTAL %	MEAN SPEED (KNOTS)
N			1.6	1.2	.4		3.7	15.1
NE		.4	1.6	2.0	4.9		10.2	18.0
E			1.6	2.5	4.5		8.0	19.8
SE				.8	1.2		2.0	14.9
S			1.6	8.0	2.0		12.7	16.8
SW			3.3	5.5	1.6		11.4	15.4
W		.4	5.3	12.4	9.6		27.8	17.7
NW			3.3	10.2	2.0		15.5	15.2
CALM	1.2						1.2	.0
TOTAL	.8	18.8	55.8	24.1	.4		100.0	17.3

NO. OF OBS: 245

MAX WIND
SPEED: 38 KNOTS
DIRECTION: 340 DEG
DAY: 11
HOUR: 09

% OF OBS WITH POTENTIAL SUPERSTRUCTURE ICING MODERATE:11.4% SEVERE: NONE #OBS: 245

DECEMBER D A T A S U M M A R Y EB41

AVERAGE LATITUDE 38.7N AVERAGE LONGITUDE 073.8W

MEANS AND EXTREMES

	MIN	(DA HR)	MEAN	MAX	(DA HR)	NO. OF OBS	DAYS WITH DATA
AIR TEMP (DEG C)	-03.9	(11 15)	07.3	16.5	(05 21)	153	20
SEA TEMP (DEG C)	10.2	(27 15)	11.6	13.7	(03 18)	153	20
AIR-SEA TEMP (DEG C)	-14.9	(10 15)	-04.1	04.2	(05 21)	153	20
PRESSURE (MBAR)	0981.2	(08 15)	1016.3	1035.8	(12 15)	153	20

WIND - % FREQUENCIES, MEANS AND EXTREMES

SPEED (KNOTS) DIR	0	4	11	22	34	>47	MEAN TOTAL %	MEAN SPEED (KNOTS)
N		.7	2.6	2.6	.7		6.5	11.6
NE		.7	2.0	5.2	4.6		12.5	17.6
E		.7	1.3	3.3	2.0		7.2	18.4
SE		.7	1.3	1.3			3.3	8.0
S		.7	3.9	7.2	.7		12.4	12.3
SW		.7	2.0	7.2	.7		10.5	13.9
W		.7	5.9	5.9	5.9		18.3	16.5
NW		.7	7.2	11.0	1.3		19.1	15.5
CALM	6						6	.0
TOTAL	6.2	26.1	46.7	19.0			100.0	14.9

NO. OF OBS: 153

MAX WIND
SPEED: 37 KNOTS
DIRECTION: 300 DEG
DAY: 10
HOUR: 03

WAVES - % FREQUENCIES, MEAN AND EXTREME (METERS) NO. OF WAVE OBS: 153

HEIGHT (M)	<1	1-1.5	2-2.5	3-3.5	4-5.5	6-7.5	8-9.5	>9.5	MEAN	MAX (DA HR)
% FREQUENCY	19.7	39.2	26.1	13.7	3.9	1.3			1.8M	7.0M (20 00)

% OF OBS WITH POTENTIAL SUPERSTRUCTURE ICING MODERATE: 7.2% SEVERE: NONE #OBS: 153

DECEMBER D A T A S U M M A R Y EB44

AVERAGE LATITUDE 26.0N AVERAGE LONGITUDE 086.0W

MEANS AND EXTREMES

	MIN	(DA HR)	MEAN	MAX	(DA HR)	NO. OF OBS	DAYS WITH DATA
AIR TEMP (DEG C)	15.2	(07 15)	21.1	25.8	(31 15)	248	31
SEA TEMP (DEG C)	22.5	(19 15)	24.9	27.0	(21 09)	243	31
AIR-SEA TEMP (DEG C)	-03.5	(22 12)	-03.8	00.4	(04 03)	243	31
PRESSURE (MBAR)	1008.4	(09 21)	1018.0	1028.8	(23 03)	248	31

WIND - % FREQUENCIES, MEANS AND EXTREMES

SPEED (KNOTS) DIR	0	4	11	22	34	>47	MEAN TOTAL %	MEAN SPEED (KNOTS)
N		.4	5.2	11.5	2.4		19.4	15.7
NE		.4	8.9	11.7	.4		21.4	11.3
E		.8	4.8	15.8			21.4	13.6
SE			4.4	7.7			12.1	11.5
S			7.3	4.8			12.1	9.9
SW			2.8	5.3			8.0	11.5
W				2.4			2.4	13.8
NW			1.2	2.0	1.2		4.4	17.6
CALM	1						1	.0
TOTAL	1.0	34.3	60.1	4.8			100.0	12.1

NO. OF OBS: 248

MAX WIND
SPEED: 24 KNOTS
DIRECTION: 300 DEG
DAY: 25
HOUR: 21

WAVES - % FREQUENCIES, MEAN AND EXTREME (METERS) NO. OF WAVE OBS: 244

HEIGHT (M)	<1	1-1.5	2-2.5	3-3.5	4-5.5	6-7.5	8-9.5	>9.5	MEAN	MAX (DA HR)
% FREQUENCY	15.6	50.2	16.4	7.0	.8				1.4M	4.0M (07 00)

Continued on page 208.

Table 19

Selected Gale and Wave Observations, North Atlantic

November and December 1977

Vessel	Nationality	Date	Position of Ship Lat. deg.	Position of Ship Long. deg.	Time GMT	Wind Dir. 10°	Wind Speed kt.	Visibility n. mi.	Present Weather code	Pressure mb.	Temperature °C. Air	Temperature °C. Sea	Sea Waves? Period sec.	Sea Waves? Height ft.	Swell Waves Dir. 10°	Swell Waves Period sec.	Swell Waves Height ft.
NORTH ATLANTIC OCEAN		NOV.															
FALSTRIA	DANISH	1	47.4 N	09.1 W	18	22	N 45	1 NM	81	1018.8	14.6		9	26			
SNOW LAND	SWEDISH	7	56.3 N	09.2 W	00	18	50	5 NM	03	985.0	10.0			41			
HARDANGER	NORWEGIAN	8	40.7 N	45.6 W	12	32	45	2 NM	81	1001.0	11.0	20.0	10	26			
SNOW LAND	SWEDISH	8	55.7 N	16.4 W	18	25	55	5 NM	02	998.0	11.0			32.5			
AMER LEGEND	AMERICAN	8	39.6 N	48.7 W	12	34	N 55	5 NM	80	1016.9	10.0	21.1			34	8	29.5
ALLISON LYKES	AMERICAN	8	35.1 N	45.2 W	18	32	45	10 NM	01	1012.8	23.3	22.8	4	14.5	32	8	29.5
EXPORT PATRIOT	AMERICAN	9	48.2 N	33.2 W	18	35	54	5 NM	60	986.0	8.0	14.4	16	23	34	>13	29.5
FJORDNES	NORWEGIAN	9	48.4 N	35.4 W	18	36	45	5 NM	25	1001.0	9.0	16.0	9	16.5			
MOBIL AERO	AMERICAN	9	39.6 N	70.2 W	00	14	45	5 NM	62	1015.9	20.0	21.2	4	6.5	09	8	14.5
FJORDNES	NORWEGIAN	10	48.5 N	34.3 W	00	98	44	5 NM	02	1008.0	10.0	16.0	9	16.5			
SNOW LAND	SWEDISH	10	52.2 N	29.5 W	00	35	50	5 NM	02	979.0	11.5		8	29.5			
OLGA TOPIC	LIBERIAN	12	48.6 N	05.3 W	06	26	42	5 NM	02	1016.0	13.0	15.0	10	16.5			
CHARLESTON	AMERICAN	12	49.0 N	06.7 W	12	28	42	2 NM	02	1017.3	15.5	13.4	6	10	28	12	18
MARGARET LYKES	AMERICAN	14	47.8 N	10.2 W	18	27	45	2 NM	25	1013.5	13.3	13.5	5	16.5	27	7	19.5
ORE MERCURY	LIBERIAN	17	37.0 N	48.5 W	12	31	45	5 NM	15	1005.0	17.0	21.1	2	8	32	7	11.5
MOBIL LUBE	AMERICAN	18	40.5 N	71.8 W	18	26	50	5 NM	00	1003.4	11.7	13.3	4	10	26	7	14.5
AMER ARCHER	AMERICAN	20	49.8 N	13.7 W	18	35	50	5 NM	27	1007.8	9.6	12.8	6	21	33	10	26
STAGHOUND	AMERICAN	21	49.1 N	12.5 W	00	35	40	10 NM	25	1004.1	7.0	12.8	8	32.5			
AMER ARCHER	AMERICAN	21	50.3 N	14.4 W	06	36	50	2 NM	79	1012.5	6.1	12.3	6	19.5	36	10	26
EXPORT BAY	AMERICAN	22	39.4 N	50.8 W	06	36	45	10 NM	02	1010.0	11.7	22.7	2	11.5			
NORSH TRIGGER	NORWEGIAN	22	41.0 N	41.9 W	18	19	N 42	10 NM	02	995.3	18.2	20.0	10	19.5			
EXPORT COMMERCE	AMERICAN	24	43.3 N	46.8 W	06	32	45	5 NM	02	1016.1	6.7	10.6	5	14.5	32	9	19.5
AMER ARCHER	AMERICAN	24	47.1 N	41.4 W	12	30	50	5 NM	02	1000.2	8.7	12.3	6	14.5	30	8	19.5
STAGHOUND	AMERICAN	25	43.5 N	41.0 W	00	30	45	10 NM	02	1018.6	8.9	13.5	4	6.5	30	6	24.5
AMER ARCHER	AMERICAN	25	46.9 N	42.8 W	00	32	50	5 NM	02	1016.0	4.5	12.3	9	32.5			
OGDEN MARASH	AMERICAN	26	31.5 N	76.2 W	18	27	45	5 NM	02	1000.5	19.0	23.3	3	8	27	< 6	16.5
STAGHOUND	AMERICAN	27	41.6 N	57.0 W	00	20	45	5 NM	80	1009.1	21.1	20.0	3	10	21	< 6	21
AMER ARCHER	AMERICAN	27	42.8 N	42.6 W	18	26	55	5 NM	02	1005.2	4.4	8.8	6	16.5	26	8	32.5
AMER ARCHER	AMERICAN	28	42.6 N	43.1 W	00	26	45	5 NM	02	1015.8	4.4	9.5		19.5	26	X	24.5
ORIENTAL EDUCATOR	BRITISH	30	16.0 N	77.0 W	00	11	N 45	2 NM	02	1011.9	28.5	25.0	3	5	07	12	10
GREAT LAKES VESSELS																	
SAMUEL MATHER	AMERICAN	11	48.0 N	89.2 W	12	33	N 42	5 NM	02		- 5.0	7.0					
SAMUEL MATHER	AMERICAN	20	43.3 N	86.7 W	12	14	N 41	5 NM	63		4.0	8.0		8			
WILFRED SYKES	AMERICAN	21	45.8 N	87.0 W	06	23	N 43	10 NM	01		1.0	7.0		5			
CHAMPLAIN	AMERICAN	26	44.8 N	83.1 W	06	32	N 48	1 NM	71		- 3.0	6.0	9	10			
J A W IGLEHART	AMERICAN	26	43.1 N	82.4 W	06	30	N 43	5 NM	00		- 4.0	7.0	2	6.5			
NORTH ATLANTIC OCEAN		NOV.															
ENVIRONMENTAL BUOYS																	
EB 07	AMERICAN	27	39.0 N	70.0 W	05	27	N 41			1003.1	5.6	17.4					
NORTH ATLANTIC OCEAN		DEC.															
ADM W M CALLAGHAN	AMERICAN	2	40.1 N	38.3 W	06	29	42	10 NM	02	1001.0	7.7	13.3	8	16.5	32	12	16.5
EXPORT AMBASSADOR	AMERICAN	2	37.6 N	30.0 W	12	26	45	10 NM	03	1000.0	16.7	19.0	3	10	30	10	13
EXPORT AMBASSADOR	AMERICAN	4	36.7 N	44.1 W	12	23	45	5 NM	03	1010.3	20.0	19.0	5	8	26	8	10
STOLT LLANDAFF	BRITISH	4	44.9 N	39.2 W	18	31	50	2 NM	62	999.8	12.6	13.2	6	13	30	9	44
ORIC	PANAMANIAN	6	36.9 N	71.6 W	18	25	N 50	10 NM	01	985.0	20.0	23.0	6	13			
MONTICELLO VICTORY	AMERICAN	6	25.1 N	87.7 W	18	01	45	10 NM	02	1015.9	26.7	24.0	6	6.5	05	>13	18
PACIFIC	SWEDISH	6	38.4 N	23.8 W	18	27	48	5 NM	03	999.5	15.5	18.0	XX	13	24	12	19.5
STAGHOUND	AMERICAN	7	40.2 N	62.5 W	18	27	41	5 NM	80	989.8	8.3	14.5	XX	10	27	8	26
EXPORT AMBASSADOR	AMERICAN	7	42.0 N	41.8 W	12	26	45	2 NM	02	980.3	8.9	12.7	5	8	26	10	10
ORIC	PANAMANIAN	7	38.1 N	72.2 W	00	29	N 50	10 NM	03	992.0	7.0	25.0	6	13			
EXXON HOUSTON	AMERICAN	7	36.5 N	72.0 W	12	27	50	5 NM	60	1014.0	11.0	20.5	5	8	28	9	19.5
EVERGREEN	AMERICAN	7	40.2 N	63.7 W	18	27	N 45	5 NM	26	993.8	8.6	14.3	10	13			
EXPORT FREEDOM	AMERICAN	7	36.9 N	27.6 W	06	32	41	10 NM	01	1013.2	14.5	17.3	5	10	30	10	23
MONTICELLO VICTORY	AMERICAN	7	25.0 N	86.3 W	00	36	45	10 NM	02	1018.6	18.9	24.5	6	11.5	33	7	11.5
MOBIL POWER	AMERICAN	7	36.0 N	72.1 W	06	29	50	10 NM	13	1001.0	10.0	22.2	XX	10	25	>13	19.5
OVERSEAS ULLA	AMERICAN	7	35.4 N	71.1 W	12	27	44	5 NM	02	1000.3	10.0	24.4	4	8	27	10	14.5
PACIFIC	SWEDISH	7	38.2 N	24.4 W	00	28	45	5 NM	02	998.0	17.0	18.5					
STAGHOUND	AMERICAN	8	40.2 N	60.1 W	00	27	41	5 NM	01	994.9	10.0	17.7	XX	8	27	8	28
AMER LEGEND	AMERICAN	8	44.1 N	39.2 W	18	26	45	5 NM	28	987.7	14.5	12.8	6	10	26	8	19.5
OVERSEAS ULLA	AMERICAN	8	34.1 N	70.5 W	00	32	42	10 NM	02	1010.8	12.2	22.8	4	11.5	32	10	16.5
AMER LEGEND	AMERICAN	9	44.0 N	40.0 W	00	24	50	10 NM	02	990.2	11.1	14.5	10	16.5	24	11	34.5
BALAO	NORWEGIAN	9	43.8 N	37.9 W	18	31	45	10 NM	25	1012.0	10.3	13.0	5	13	28	12	26
MONTICELLO VICTORY	AMERICAN	9	35.3 N	73.0 W	18	19	45	10 NM	02	1014.6	21.7	26.7	5	10			
EXPORT FREEDOM	AMERICAN	9	38.3 N	45.6 W	18	34	48	10 NM	01	1020.0	11.7	20.0	5	6.5	31	11	14.5
BALAO	NORWEGIAN	10	45.8 N	34.0 W	12	31	50	5 NM	28	1013.0	12.3	11.7	8	16.5	30	12	29.5
EVERGREEN	AMERICAN	10	39.7 N	63.6 W	06	25	N 60	2 NM	64	1002.0		23.0	8	18			
MOBIL AERO	AMERICAN	10	39.7 N	72.6 W	12	30	47	10 NM	02	1021.0	0.6	13.0	5	8	30	8	23
EXPORT FREEDOM	AMERICAN	10	39.2 N	53.6 W	18	21	45	2 NM	07	1004.1	18.4	21.1	5	6.5	23	10	18
BALAO	NORWEGIAN	11	47.1 N	32.1 W	00	28	48	10 NM	28	1018.3	11.3		7	16.5	30	12	32.5
EXPORT FREEDOM	AMERICAN	11	39.5 N	38.6 W	12	28	45	10 NM	01	1009.5	10.6	18.8	4	6.5	29	9	24.5
EXPORT FREEDOM	AMERICAN	12	39.5 N	38.8 W	00	29	45	10 NM	27	1012.0	5.6	19.4	4	6.5	32	8	24.5
BERGLJOT	NORWEGIAN	13	42.1 N	30.8 W	06	22	N 45	2 NM	81	1016.0	15.5	14.0					
MONTICELLO VICTORY	AMERICAN	14	32.7 N	75.8 W	18	16	45	10 NM	02	1016.6	21.2	22.2	5	14.5			
DON JUAN	SWEDISH	16	43.9 N	46.8 W	18	23	50	50 YD		996.0	14.0				23	8	32.5
YOUNG AMERICA	AMERICAN	19	37.6 N	57.2 W	12	27	45	5 NM	29	990.5	18.2	18.9	8	16.5	23	8	19.5
MOBIL LUBE	AMERICAN	19	33.5 N	74.1 W	18	32	50	.25 NM	49	993.9	15.6	28.7	4	11.5	33	7	19.5
OVERSEAS ULLA	AMERICAN	19	33.7 N	74.2 W	12	30	48	1 NM		987.0	14.0	26.7	5	8	30	6	14.5
EDGAR M QUEENY	AMERICAN	19	37.5 N	74.3 W	14	04	42	1 NM	65	999.3	12.2	15.0	XX	24.5	03	12	34.5
SEALAND MARKET	AMERICAN	19	37.3 N	72.0 W	12	09	45	2 NM	81	991.7	18.3	21.5	12	16.5	09	9	19.5
SHERMAN	AMERICAN	19	39.2 N	72.7 W	12	08	N 42	1 NM	50	1004.7	10.2	11.1	3	11.5			
BALTIMORE TRADER	AMERICAN	19	35.3 N	74.4 W	18	32	50	1 NM		999.8	13.9	25.0	5	24.5	32	X	29.5
LORD DORLEANS	PANAMANIAN	20	35.6 N	74.5 W	00	34	40	2 NM	02	1008.0	15.6		8	32.5	34	10	41
OVERSEAS ULLA	AMERICAN	20	36.3 N	74.2 W	00	36	45	2 NM	02	1004.0	13.4	25.0	11	36			
TRANSCOLUMBIA	AMERICAN	20	42.4 N	33.2 W	12	22	50	10 NM	01	981.0	13.9	12.3	2	11.5	23	>13	19.5
SEALAND MARKET	AMERICAN	20	36.7 N	70.3 W	00	02	50	1 NM	81	991.5	18.2	20.5	9	16.5			
AMER ACCORD	AMERICAN	20	43.7 N	32.3 W	12	28	45	10 NM	02	980.0	12.8	13.3	5	14.5			
GREEN VALLEY	AMERICAN	21	31.8 N	38.1 W	18	23	N 56	5 NM	18	1003.0	21.1	20.0	7	29.5			
TRANSCOLUMBIA	AMERICAN	21	40.9 N	25.8 W	00	26	45	5 NM	02	997.2	13.9	12.2	3	14.5	26	6	18
STAGHOUND	AMERICAN	21	30.5 N	16.8 W	00	17	44	5 NM	02	986.5	12.3	11.7	6	6.5			
ALMERIA LYKES	AMERICAN	21	47.8 N	09.8 W	00	14	45	5 NM	50	997.0	12.3	11.2	3	6.5	13	7	11.5

Vessel	Nationality	Date	Position of Ship		Time	Wind		Visibility	Present	Pressure	Temperature °C		Sea Waves*		Swell Waves		
			Lat. deg.	Long. deg.	GMT	Dir. 10°	Speed kt.	n. mi.	Weather code	mb.	Air	Sea	Period sec.	Height ft.	Dir. 10°	Period sec.	Height ft.
NORTH ATLANTIC OCEAN		DEC.															
EXPORT COURIER	AMERICAN	22	36.7 N	28.0 W	18	19	60	2 NM	02	987.5	19.5	17.3	6	13	18	7	18
MONTICELLO VICTORY	AMERICAN	22	25.6 N	48.4 W	06	32	45	10 NM	02	1022.7	15.6	23.8	6	18			
NORTH	AMERICAN	22	33.2 N	31.1 W	12	21	60	2 NM	64	992.9	20.0	18.4			21	< 6	29.5
STAGHOUND	AMERICAN	22	49.2 N	25.9 W	06	23	45	5 NM	01	978.0	10.0	13.4	4	16.5	24	12	41
TRANSCOLUMBIA	AMERICAN	22	36.6 N	35.1 W	18	34	45	10 NM	02	1005.8	12.7	10.2	3	8	35	7	11.5
COLUMBIA	AMERICAN	23	43.1 N	09.4 W	12	18	45	5 NM	20	1021.0	16.2	11.7	5	11.5	20	10	19.5
JOHN TYLER	AMERICAN	23	48.1 N	08.2 W	18	21	55	2 NM	30	1008.1	14.4	11.7	10	16.5			
TRANSCOLUMBIA	AMERICAN	23	36.6 N	36.6 W	00	32	45	10 NM	01	1011.3	12.7	10.1	3	8	35	7	11.5
STAGHOUND	AMERICAN	23	48.0 N	33.7 W	06	36	45	5 NM	02	1000.7	10.0	13.9	4	13	33	9	32.5
GREEN ISLAND	AMERICAN	26	36.3 N	64.5 W	06	20	M 45	5 NM	02	1009.4	20.0	20.6	8	14.5			
TRANSCOLUMBIA	AMERICAN	26	36.7 N	64.1 W	18	20	45	5 NM	29	999.7	18.7	20.0	4	14.5	23	< 6	16.5
AMER ALLIANCE	AMERICAN	26	49.7 N	70.3 W	18	32	45	10 NM	81	1029.8	7.7	11.6	8	26	33	8	11.5
DOCTOR LYKES	AMERICAN	28	35.6 N	51.6 W	18	14	45	2 NM	18	1015.2	20.0	20.0	5	8	16	6	11.5
GREAT LAKES VESSELS																	
SAMUEL MATHER	AMERICAN	2	41.8 N	81.7 W	00	24	M 44	5 NM	02		4.0	8.0		10			
ERNEST R BREECH	AMERICAN	9	44.3 N	81.8 W	00	12	M 42	2 NM	71		- 5.0	5.0		11.5			
CHARLES M WHITE	AMERICAN	12	47.0 N	87.5 W	06	20	M 42	1 NM	22		-10.0	4.0	4	8			
G M HUMPHREY	AMERICAN	17	48.0 N	89.3 W	18	11	M 48	10 NM	02		2.0	7.0	6	8			
NORTH ATLANTIC OCEAN		DEC.															
ENVIRONMENTAL BUOYS																	
EB 07	AMERICAN	7	39.0 N	70.0 W	12	28	M 45			998.4	3.6	16.7	8	18			
EB 07	AMERICAN	19	39.0 N	70.0 W	21	05	M 44			1007.2	9.3	17.8	8	23			
EB 07	AMERICAN	20	39.0 N	70.0 W	00	04	M 41			1009.3	9.0	19.2	8	23			

* Direction for sea waves same as wind direction
X Direction or period of waves indeterminate
M Measured wind

NOTE: The observations are selected from those with winds ≥ 35 kn or waves ≥ 25 ft from May through August (≥ 41 kn or ≥ 33 ft, September through April). In cases where a ship reported more than one observation a day with such values, the one with the highest wind speed was selected.

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NOVEMBER — DATA SUMMARY — E845

AVERAGE LATITUDE 60.2N — AVERAGE LONGITUDE 148.8W

MEANS AND EXTREMES	MIN	(DA HR)	MEAN	MAX	(DA HR)	NO. OF 885 DATA	DAYS WITH DATA
AIR TEMP (DEG C)	-02.1	(18 09)	01.7	04.6	(22 03)	223	30
SEA TEMP (DEG C)	03.8	(25 00)	05.7	08.8	(03 03)	222	30
AIR-SEA TEMP (DEG C)	-08.4	(10 12)	-05.4	-02.4	(21 08)	219	30
PRESSURE (MBAR)	0974.1	(14 09)	1004.7	1040.5	(18 12)	225	30

WIND - % FREQUENCIES, MEANS AND EXTREMES

DIR	SPEED (KNOTS) <4	4-10	11-21	22-33	34-47	>47	TOTAL %	MEAN SPEED (KNOTS)
N	2.7	15.3	5.0				23.0	7.3
NE	3.2	9.5	9.4				16.0	7.8
E	2.3	9.0	6.8				18.1	8.2
SE	.5	1.4	.8				2.7	8.8
S	.5	1.8	2.7				5.0	10.4
SW		2.7	1.4				4.1	8.2
W	.5	1.4	.8				2.7	7.8
NW		11.3	14.8				26.1	10.8
CALM	.5						.5	.0
TOTAL %	9.8	52.3	37.8				100.0	8.7

NO. OF 885: 222
MAX WIND SPEED: 18 KNOTS DIRECTION: 330 DEG DAY: 11 HOUR: 18

NOVEMBER — DATA SUMMARY — E871

AVERAGE LATITUDE 28.0N — AVERAGE LONGITUDE 083.5W

MEANS AND EXTREMES	MIN	(DA HR)	MEAN	MAX	(DA HR)	NO. OF 885 DATA	DAYS WITH DATA
AIR TEMP (DEG C)	17.3	(10 12)	23.5	28.7	(08 18)	240	30
SEA TEMP (DEG C)	25.1	(30 21)	25.8	27.4	(01 00)	240	30
AIR-SEA TEMP (DEG C)	-09.8	(10 12)	-02.4	00.3	(20 21)	240	30
PRESSURE (MBAR)	1006.1	(08 21)	1015.0	1030.1	(12 15)	240	30

WIND - % FREQUENCIES, MEANS AND EXTREMES

DIR	SPEED (KNOTS) <4	4-10	11-21	22-33	34-47	>47	TOTAL %	MEAN SPEED (KNOTS)
N	.4	3.8	9.8	9.0			19.4	18.8
NE		3.8	3.3				7.1	11.3
E		5.0	3.3	.4			8.8	10.5
SE	.4	3.8	18.3	3.3			25.8	15.2
S		6.0	14.2	1.7			20.8	14.4
SW			1.5				2.1	11.2
W		3.8	2.5				6.3	10.1
NW		1.3	12.1	.4			13.8	16.8
CALM								
TOTAL %	1.3	27.1	65.8	10.8			100.0	14.2

NO. OF 885: 240
MAX WIND SPEED: 32 KNOTS DIRECTION: 360 DEG DAY: 22 HOUR: 08

WAVES - % FREQUENCIES, MEAN AND EXTREME (METERS)

HEIGHT (M)	<1	1-1.5	2-2.5	3-3.5	4-5.5	6-7.5	8-9.5	>9.5	MEAN	MAX (DA HR)
% FREQUENCY	18.0	57.5	21.3	2.5	.8				1.4M	4.0M (10 08)

NO. OF WAVE 885: 238

NOVEMBER — DATA SUMMARY — E873

AVERAGE LATITUDE 57.1N — AVERAGE LONGITUDE 151.7W

MEANS AND EXTREMES	MIN	(DA HR)	MEAN	MAX	(DA HR)	NO. OF 885 DATA	DAYS WITH DATA
AIR TEMP (DEG C)	-04.4	(18 00)	02.4	09.5	(20 08)	239	30
SEA TEMP (DEG C)	05.3	(30 21)	06.0	07.8	(01 12)	238	30
AIR-SEA TEMP (DEG C)	-10.5	(15 12)	-03.7	00.1	(20 06)	238	30
PRESSURE (MBAR)	0976.4	(13 15)	1004.5	1036.0	(18 03)	238	30

WIND - % FREQUENCIES, MEANS AND EXTREMES

DIR	SPEED (KNOTS) <4	4-10	11-21	22-33	34-47	>47	TOTAL %	MEAN SPEED (KNOTS)
N	.4	4.2	10.0	.8			15.5	13.8
NE	1.3	2.9	8.3	2.9			15.0	14.7
E	.4	3.3	9.2	19.1			31.9	18.0
SE	.4	1.7	2.5	2.5			7.1	16.1
S	.4	1.7	4.6	.4			7.1	13.3
SW	.4	1.7	10.5	1.3			13.8	15.7
W	.4	5.0	5.9	1.3			12.9	13.4
NW		2.5	3.3				5.8	11.1
CALM								
TOTAL %	3.8	23.8	48.4	23.8			100.0	16.7

NO. OF 885: 239
MAX WIND SPEED: 32 KNOTS DIRECTION: 080 DEG DAY: 23 HOUR: 18

WAVES - % FREQUENCIES, MEAN AND EXTREME (METERS)

HEIGHT (M)	<1	1-1.5	2-2.5	3-3.5	4-5.5	6-7.5	8-9.5	>9.5	MEAN	MAX (DA HR)
% FREQUENCY	.8	32.8	30.3	18.0	17.9	.4			2.8M	8.0M (19 03)

NO. OF WAVE 885: 228

% OF 885 WITH POTENTIAL SUPERSTRUCTURE ICING MODERATE: 9.0% SEVERE: NONE 0885: 239

DECEMBER — DATA SUMMARY — E845

AVERAGE LATITUDE 60.2N — AVERAGE LONGITUDE 148.8W

MEANS AND EXTREMES	MIN	(DA HR)	MEAN	MAX	(DA HR)	NO. OF 885 DATA	DAYS WITH DATA
AIR TEMP (DEG C)	-08.8	(03 12)	00.2	04.2	(26 21)	230	31
SEA TEMP (DEG C)	02.4	(25 18)	05.1	08.6	(14 08)	221	31
AIR-SEA TEMP (DEG C)	-11.1	(03 18)	-04.9	00.5	(26 00)	220	31
PRESSURE (MBAR)	0983.7	(14 18)	1011.8	1034.3	(08 12)	220	31

WIND - % FREQUENCIES, MEANS AND EXTREMES

DIR	SPEED (KNOTS) <4	4-10	11-21	22-33	34-47	>47	TOTAL %	MEAN SPEED (KNOTS)
N	.9	11.8	17.1	.8	.9		30.8	12.7
NE		7.9	10.2	.9			18.9	11.3
E	1.4	11.8	10.2	.9			24.1	8.8
SE	.9	2.3	2.3	.5	.5		6.0	14.0
S			.9				.9	13.1
SW								
W	.5		.5				.9	17.6
NW		7.9	10.2	.9			18.9	10.9
CALM	.9						.9	.0
TOTAL %	3.7	41.2	50.8	3.3	1.4	.5	100.0	11.6

NO. OF 885: 216

% OF 885 WITH POTENTIAL SUPERSTRUCTURE ICING MODERATE:10.7% SEVERE: NONE 0885: 219

DECEMBER — DATA SUMMARY — E871

AVERAGE LATITUDE 28.0N — AVERAGE LONGITUDE 083.5W

MEANS AND EXTREMES	MIN	(DA HR)	MEAN	MAX	(DA HR)	NO. OF 885 DATA	DAYS WITH DATA
AIR TEMP (DEG C)	17.4	(07 12)	23.5	29.3	(05 21)	73	10
SEA TEMP (DEG C)	24.1	(29 12)	24.8	25.2	(02 18)	72	10
AIR-SEA TEMP (DEG C)	-07.2	(07 06)	-02.9	00.4	(05 18)	72	10
PRESSURE (MBAR)	1004.9	(05 21)	1014.9	1025.0	(07 03)	73	10

WIND - % FREQUENCIES, MEANS AND EXTREMES

DIR	SPEED (KNOTS) <4	4-10	11-21	22-33	34-47	>47	TOTAL %	MEAN SPEED (KNOTS)
N		1.4	11.8	2.7			15.1	18.8
NE		1.4	9.2	1.4			11.8	16.3
E		8.8	9.5				18.3	9.1
SE		8.8	16.4				25.3	13.1
S			28.0				28.0	18.2
SW			2.7				2.7	14.5
W		2.7	1.4				4.1	8.7
NW		2.7					2.7	9.8
CALM								
TOTAL %		31.8	74.8	4.1			100.0	14.5

NO. OF 885: 73
MAX WIND SPEED: 30 KNOTS DIRECTION: 020 DEG DAY: 18 HOUR: 00

WAVES - % FREQUENCIES, MEAN AND EXTREME (METERS)

HEIGHT (M)	<1	1-1.5	2-2.5	3-3.5	4-5.5	6-7.5	8-9.5	>9.5	MEAN	MAX (DA HR)
% FREQUENCY	4.1	72.6	18.4	4.8					1.5M	3.5M (06 18)

NO. OF WAVE 885: 73

DECEMBER — DATA SUMMARY — E873

AVERAGE LATITUDE 57.1N — AVERAGE LONGITUDE 151.7W

MEANS AND EXTREMES	MIN	(DA HR)	MEAN	MAX	(DA HR)	NO. OF 885 DATA	DAYS WITH DATA
AIR TEMP (DEG C)	-07.9	(12 08)	00.9	04.7	(01 21)	242	31
SEA TEMP (DEG C)	03.9	(30 21)	04.4	05.4	(01 00)	242	31
AIR-SEA TEMP (DEG C)	-11.6	(12 12)	-03.6	00.7	(21 06)	242	31
PRESSURE (MBAR)	0959.5	(14 21)	1010.8	1028.8	(08 06)	242	31

WIND - % FREQUENCIES, MEANS AND EXTREMES

DIR	SPEED (KNOTS) <4	4-10	11-21	22-33	34-47	>47	TOTAL %	MEAN SPEED (KNOTS)
N	.4	3.3	23.2	3.7	.8		31.5	17.4
NE	.4	2.1	3.3	1.2			7.1	14.1
E		5.8	3.3	.8			10.0	18.4
SE	.4	3.3	4.1	.4			8.3	11.5
S		8.8	2.5				11.2	11.2
SW		5.0	2.5				7.5	8.7
W		3.3	1.2	.4			5.0	10.0
NW		5.3	8.1	2.9	.4		16.8	16.3
CALM								
TOTAL %	1.2	39.8	97.7	10.8	1.2		100.0	14.5

NO. OF 885: 241
MAX WIND SPEED: 44 KNOTS DIRECTION: 330 DEG DAY: 14 HOUR: 18

WAVES - % FREQUENCIES, MEAN AND EXTREME (METERS)

HEIGHT (M)	<1	1-1.5	2-2.5	3-3.5	4-5.5	6-7.5	8-9.5	>9.5	MEAN	MAX (DA HR)
% FREQUENCY		38.1	36.8	14.4	5.0	1.3	.4		2.2M	8.0M (14 21)

NO. OF WAVE 885: 236

% OF 885 WITH POTENTIAL SUPERSTRUCTURE ICING MODERATE:14.1% SEVERE: NONE 0885: 241

Table 20
Selected Gale and Wave Observations, North Pacific
November and December 1977

Vessel	Nationality	Date	Position of Ship Lat. deg.	Position of Ship Long. deg.	Time GMT	Wind Dir. 10°	Wind Speed kt.	Visibility n. mi.	Present Weather code	Pressure mb.	Temperature °C Air	Temperature °C Sea	Sea Waves† Period sec.	Sea Waves† Height ft.	Swell Waves Dir. 10°	Swell Waves Period sec.	Swell Waves Height ft.
NORTH PACIFIC OCEAN		NOV.															
OVERSEAS CHICAGO	AMERICAN	1	43.3 N	128.9 W	18	21	55	5 NM	02	1009.2	16.7	13.4	5	8	21	9	16.5
WASHINGTON RAINBOW	JAPANESE	3	21.2 N	157.1 W	18	09	M 45	2 NM	04	1015.0	23.0	23.0	5	8			
PRESIDENT MADISON	AMERICAN	4	48.9 N	129.5 W	12	14	M 52	10 NM	02	1000.2	11.1	11.7	7	14.5	18	X	16.5
BELLADONA VENTURE	LIBERIAN	4	46.2 N	125.3 W	17	14	M 41	10 NM	02	999.5	11.0	14.0	9	10			
PRES JEFFERSON	AMERICAN	5	41.5 N	140.5 W	00	32	35	10 NM	02	1019.5	13.9	12.8	2	8	32	< 6	32.5
ARCO FAIRBANKS	AMERICAN	7	49.9 N	134.2 W	06	29	M 43	10 NM	01	1022.6	8.0	8.9	3	10	29	10	26
MOBIL MERIDIAN	AMERICAN	7	54.9 N	138.7 W	06	27	50	5 NM	85	1010.5	4.5	8.9	6	8	28	9	24.5
NEWARK	AMERICAN	7	57.9 N	147.9 W	00	31	50	> 25 NM	02	999.3	2.3	6.7	4	8	31	7	20
ALEUTIAN DEVELOPER	AMERICAN	8	55.2 N	160.0 W	18	14	45	2 NM	61	999.9	3.3	7.8	3	6.5			
PRESIDENT MADISON	AMERICAN	9	50.3 N	133.8 W	00	36	M 48	5 NM	01	1000.6	10.0	11.7	5	10	34	7	14.5
ALBUTIAN DEVELOPER	AMERICAN	9	56.0 N	158.0 W	00	16	55	1 NM	65	995.3	3.9	7.2	5	19.5			
GREAT LAND	AMERICAN	11	51.3 N	130.4 W	12	16	M 48	2 NM	62	987.8	12.8	10.6	5	14.5			
WESTWARD VENTURE	AMERICAN	11	50.8 N	129.4 W	12	16	M 50	1 NM	65	989.2	10.5	10.6					
PRESIDENT MADISON	AMERICAN	12	49.6 N	176.5 E	18	27	M 60	5 NM	02	991.9	3.3	7.2			27	>13	24.5
ORIENTAL SOVERIGN	LIBERIAN	12	51.4 N	176.4 W	06	27	M 47	5 NM	01	999.0	6.0	6.5	10	13			
SINCLAIR TEXAS	AMERICAN	13	46.7 N	132.8 W	18	18	39	2 NM	62	1001.4	10.0	8.3			XX	X	29.5
PRESIDENT MADISON	AMERICAN	13	49.0 N	174.7 E	00	27	M 45	10 NM	02	992.5	2.2	7.2	8	23			
ORIENTAL SOVERIGN	LIBERIAN	13	50.8 N	179.2 E	06	28	M 47	5 NM	88	979.0	5.0	5.5	12	24.5			
JAPAN RAINBOW	JAPANESE	13	30.9 N	132.2 E	12	04	M 52	1 NM	05	1020.0	22.0	24.0			04	6	6.5
MOBIL OIL	AMERICAN	13	51.5 N	132.0 W	18	18	M 42	2 NM	60	993.9	7.2	9.4	5	10	20	8	13
BEISHU MARU	JAPANESE	13	50.3 N	136.7 W	18	23	M 43	1 NM	65	981.0	10.0	7.0	3	10	22	< 6	16.5
EXXON SAN FRANCISCO	AMERICAN	13	52.2 N	135.2 W	18	16	50	1 NM	61	982.0	8.0	10.0	4	26			
ARCO FAIRBANKS	AMERICAN	14	49.1 N	127.8 W	00	15	M 42	5 NM	66	1001.0	12.0	9.5	5	8	17	9	24.5
YOCONA	AMERICAN	14	50.9 N	136.4 W	06	25	50	5 NM	14	990.5	7.8	10.6	10	10	24	9	18
WESTWARD VENTURE	AMERICAN	14	55.2 N	139.5 W	12	26	45	.5 NM	69	976.2	6.5	8.3			27	X	23
JAPAN RAINBOW	JAPANESE	14	30.4 N	134.4 E	06	06	M 50	5 NM	03	1017.0	23.0	23.0			06	6	6.5
MOBIL MERIDIAN	AMERICAN	14	49.1 N	128.3 W	00	18	48	.5 NM	53	999.5	10.0	10.0	5	8	19	9	16.5
MOBIL OIL	AMERICAN	14	51.3 N	131.2 W	00	25	M 43	5 NM	21	987.8	9.4	9.4	5	8	25	8	21
PHILADELPHIA	AMERICAN	14	54.5 N	136.7 W	12	25	60	5 NM	64	977.7	6.7	7.8	4	14.5	25	< 6	32.5
MONTIGNY	LIBERIAN	14	48.8 N	136.9 W	00	24	M 42	5 NM	01	990.6	10.0	7.0	8	16.5	24	11	21
BEISHU MARU	JAPANESE	14	52.7 N	139.9 W	06	25	M 52	.5 NM	07	975.6	5.0	4.5					
EXXON SAN FRANCISCO	AMERICAN	14	51.3 N	133.3 W	18	25	28	10 NM	02	1007.2	11.8	10.0	6	32.5	18	>13	39
CORAL ARCADIA		14	50.7 N	131.6 W	12	27	M 48	2 NM	60	1002.0	8.0	11.5	8	19.5			
YAMASHIN MARU	JAPANESE	16	39.2 N	149.6 W	18	05	M 50	.5 NM	21	1018.0	10.0	15.0	6	13	33	10	16.5
YOCONA	AMERICAN	16	50.9 N	135.5 W	06	31	54	5 NM	02	1020.7	3.6	8.9	9	32.5	26	12	5
GREEN AUKLET	PANAMANIAN	16	34.3 N	137.4 E	06	06	M 55	.5 NM	21	1018.0	18.0	24.0	5	8			
OVERSEAS ARCTIC	AMERICAN	16	51.9 N	138.6 W	00	31	45	5 NM	27	1015.1	5.6	8.7			29	9	16.5
ORIENTAL SOVERIGN	LIBERIAN	16	46.5 N	136.0 E	12	31	M 43	5 NM	62	1014.0	4.0	8.0	8	13			
SEALAND FINANCE	AMERICAN	16	36.3 N	173.6 W	18	16	43	2 NM	63	996.5	17.0	16.7	11	19.5			
AMER AQUARIUS	AMERICAN	16	37.8 N	150.9 W	18	04	48	1 NM	60	1014.0	10.0	14.4	7	16.5	05	7	19.5
EASTERN TREASURE	LIBERIAN	17	33.4 N	144.0 W	12	18	M 45	.5 NM	07	1006.0	18.5	20.0	6	16.5			
KOREA PHOENIX	SINGAPORE	17	35.9 N	130.5 E	05	34	M 44	10 NM	03	1009.0	17.0		5	8			
JAPAN ACE	JAPANESE	17	36.9 N	144.3 W	18	23	M 43	10 NM	25	1010.0	17.0	14.0	5	6.5	23	9	10
YAMASHIN MARU	JAPANESE	17	38.8 N	152.2 W	00	06	M 46	.5 NM	63	1014.0	12.0	12.0	6	13	05	10	19.5
PRES TRUMAN	AMERICAN	17	40.9 N	171.0 W	06	31	50	1 NM	10	984.1	6.1	12.8			15	< 6	29.5
VIOLET	LIBERIAN	18	35.0 N	170.7 W	06	27	M 43	2 NM	81	1000.0	16.0	20.0	6	8	29	9	8
CORAL ARCADIA		18	54.1 N	161.6 W	06	13	M 47	5 NM	02	1006.0	4.5	7.5			22	13	23
SEATRAIN VALLEY FORGE	GERMAN	18	40.0 N	175.4 E	00	34	48	5 NM	25	1006.2	7.2	13.0	8	13	32	10	29.5
ALBUTIAN DEVELOPER	AMERICAN	18	54.0 N	163.8 W	12	11	65	2 NM	02	993.2	6.7	6.7	7	32.5			
VAN CONQUEROR	LIBERIAN	19	43.8 N	145.4 W	18	12	M 44	2 NM	02	1009.0	8.0	13.0					
VIOLET	LIBERIAN	19	32.6 N	176.3 W	06	25	M 48	2 NM	81	1006.0	20.0	21.0	6	8	25	9	10
PRES POLK	AMERICAN	19	33.7 N	179.6 E	06	26	45	5 NM	02	1004.9	18.9	18.4	9	16.5			
PRES JOHNSON	AMERICAN	19	34.2 N	165.3 W	18	14	45	5 NM	61	981.2	8.5	5.0					
VAN CONQUEROR	LIBERIAN	20	45.6 N	147.1 W	00	09	M 41	2 NM	10	1004.0	7.0	13.0					
PRES JOHNSON	AMERICAN	20	34.0 N	172.4 W	06	23	45	5 NM	03	981.2	3.3	4.4					
ALBUTIAN DEVELOPER	AMERICAN	20	56.0 N	134.5 W	12	10	50	2 NM	02	1014.9	5.6	5.6	5	14.5	10	10	29.5
KOREA PHOENIX	SINGAPORE	21	43.0 N	159.7 E	03	09	M 50	5 NM	09	1005.0	8.0		8	10			
EXXON NEW ORLEANS	AMERICAN	21	41.0 N	125.7 W	06	18	50	5 NM	63	1000.3	10.0	13.4	XX	10			
SHINYO MARU	JAPANESE	21	54.0 N	157.5 W	03	10	M 46	2 NM	19	1004.5	5.0	4.5	6	13	12	11	14.5
MORGENTHAU	AMERICAN	22	54.4 N	162.3 W	00	08	M 42	5 NM	02	1001.0	6.0	7.8	5	16.5			
VAN CONQUEROR	LIBERIAN	22	43.1 N	145.1 W	12	02	M 45	5 NM	62	985.0	5.0	11.0					
SHINYO MARU	JAPANESE	22	54.4 N	167.2 W	00	09	M 43	.5 NM	80	997.0	6.8	8.0	6	13	09	10	13
ARCO PRUDHOE BAY	AMERICAN	22	55.5 N	145.2 W	18	09	49	5 NM	07	1014.8	2.7	8.0	5	19.5	08	7	24.5
LONG BEACH	PANAMANIAN	23	43.1 N	135.8 W	00	20	M 41	10 NM	03	1013.5	12.0	10.0	10	10			
JAPAN BEAR	AMERICAN	23	43.0 N	159.8 E	12	14	M 46	5 NM	59	1008.8	10.7	11.7	4	13			
PHILADELPHIA	AMERICAN	23	56.3 N	148.1 W	18	07	48	10 NM	02	1010.5	2.2	5.6	4	13	09	8	19.5
PRES MCKINLEY	AMERICAN	23	34.9 N	143.2 E	06	23	42	10 NM	01	1009.0	18.6	21.6	7	10	26	10	19.5
ARCO PRUDHOE BAY	AMERICAN	23	51.5 N	138.6 W	21	09	57	1 NM	07	989.8	3.4	9.7	6	23	10	10	29.5
THOMAS E CUFFE	AMERICAN	24	50.0 N	158.3 W	06	03	42	5 NM	02	984.0	3.9	3.5	3	6.5	03	9	16.5
UNIQUE FORTUNE	LIBERIAN	24	30.2 N	143.2 W	00	28	45	5 NM	81	1005.0	18.0	24.0			28	X	24.5
PRES JEFFERSON	AMERICAN	24	40.8 N	146.8 E	18	36	50	10 NM	02	1002.5	10.6	13.9	6	23	36	8	29.5
PHILADELPHIA	AMERICAN	24	55.8 N	144.8 W	00	07	60	5 NM	84	1005.8	1.7	6.7	4	16.5	07	6	32.5
JAPAN BEAR	AMERICAN	24	44.6 N	165.0 E	00	14	M 44	10 NM	02	1010.8	6.2	7.8	3	11.5	12	6	19.5
LONG BEACH	PANAMANIAN	24	39.5 N	142.9 W	12	20	M 41	10 NM	03	1004.5	14.5	13.0					
KOREAN LEADER	KOREAN	24	31.1 N	139.1 W	00	27	M 43	5 NM	03	999.9	19.2	22.0	5	8	22	8	14.5
GREEN ECHO	LIBERIAN	24	48.5 N	144.0 W	00	26	M 42	2 NM	10	987.0	9.5	7.0	12	23			
OVERSEAS NATALIE	AMERICAN	24	50.3 N	129.7 W	00	13	35	2 NM	02	997.0	4.5	7.7	3	32.5			
ORIENTAL SOVERIGN	LIBERIAN	24	43.4 N	151.0 E	00	30	M 41	5 NM	02	1010.0	4.0	6.0	6	8			
CALIFORNIAN	AMERICAN	24	28.2 N	150.8 W	12	20	45	10 NM	09	1010.0	22.8	22.8			20	< 6	13
PHILADELPHIA	AMERICAN	25	52.5 N	134.5 W	12	16	49	5 NM	02	986.8	8.9	6.7	4	10	16	< 6	24.5
AMERICA MARU	JAPANESE	25	29.7 N	176.7 W	00	21	M 50	2 NM	07	1004.0	22.0	21.0	5	13	26	9	21
SEATRAIN LEXINGTON	GERMAN	25	34.1 N	167.7 E	18	33	44	10 NM	15	1014.8	15.3	20.6		18	XX	X	23
VAN CONQUEROR	LIBERIAN	25	39.4 N	171.5 E	18	10	M 44	5 NM	62	1007.0	8.0	18.0					
SEATRAIN LEXINGTON	GERMAN	26	34.1 N	166.3 E	00	33	44	10 NM	25	1018.0	18.3	20.0	8	16.5	31	X	23
TOYOTA MARU #12	JAPANESE	26	42.5 N	150.0 W	12	25	M 50	2 NM	02	992.0	9.0	10.0	6	16.5	24	9	19.5
LING YUNG	CHINESE	26	44.9 N	147.1 W	18	25	M 48	1 NM	51	990.0	9.0	10.0	4	10	25	8	23
VAN UNION	LIBERIAN	26	43.3 N	147.7 W	18	24	42	2 NM	50	987.0	10.0		11	16.5	24	8	16.5
PRESIDENT MADISON	AMERICAN	27	39.4 N	149.1 E	12	11	M 34	5 NM	60	1013.0	12.0	17.8	7	24.5			
PACBARONESS	LIBERIAN	27	45.1 N	143.5 W	00	28	M 45	5 NM	10	1002.5	10.0	11.0	6	11.5	26	13	36

Vessel	Nationality	Date	Position of Ship		Time GMT	Wind		Visibility n. mi.	Present Weather code	Pressure mb.	Temperature °C.		Sea Waves*		Swell Waves		
			Lat. deg.	Long. deg.		Dir. 10°	Speed kt.				Air	Sea	Period sec.	Height ft.	Dir. 10°	Period sec.	Height ft.
NORTH PACIFIC OCEAN		NOV.															
PRES TRUMAN	AMERICAN	27	48.4 N	138.5 W	12	27	50	5 NM	07	1008.5	6.7	10.0	5	13	27	< 6	24.5
LING YUNG	CHINESE	27	45.6 N	144.7 W	00	27	M 42	2 NM	03	1002.0	8.5	9.0	4	11.5	25	9	19.5
JAPAN BEAR	AMERICAN	27	45.6 N	134.7 W	12	22	M 36	5 NM	01	993.0	7.2	8.7	3	13	20	10	23
MICHIGAN	AMERICAN	27	33.9 N	144.1 E	00	08	45	1 NM	61	1002.0	17.2	21.1	6	8	10	7	13
LONG BEACH	PANAMANIAN	27	35.0 N	156.7 W	18	27	M 44	2 NM	02	1004.5	17.0	16.0	14	24.5	27	>13	28
PRES KENNEDY	AMERICAN	27	38.0 N	147.9 E	12	10	42	5 NM	02	1007.1	16.7	18.3	4	5	10	7	13
SEATRAIN VALLEY FORGE	GERMAN	27	37.3 N	148.4 E	18	07	50	2 NM	62	1010.0	16.5		7	13	08	6	32.5
JAPAN BEAR	AMERICAN	28	44.1 N	144.1 W	00	21	M 36	2 NM	50	994.5	12.8	7.2	3	13			
VAN CONQUEROR	LIBERIAN	28	37.1 N	153.7 E	06	10	M 45	5 NM	02	1014.0	16.0	20.0					
SEATRAIN VALLEY FORGE	GERMAN	28	37.3 N	149.3 E	00	09	52	10 NM	02	1011.9	17.1	20.0	6	13	10	6	36
CHEVRON MISSISSIPPI	AMERICAN	29	53.2 N	141.9 W	00	27	45	5 NM	02	995.2	5.0	7.2	3	6.5	27	< 6	14.5
PHILADELPHIA	AMERICAN	29	52.7 N	134.6 W	00	29	50	5 NM	63	989.5	6.1	8.9	4	13	29	< 6	16.5
SEATRAIN VALLEY FORGE	GERMAN	29	39.1 N	154.0 E	00	14	50	2 NM	62	1013.9	16.0	17.0	6	13	XX	X	19.5
VAN WARRIOR	LIBERIAN	30	43.9 N	156.4 E	18	20	45	.5 NM	62	1003.0	12.0	7.0					
PRES EISENHOWER	AMERICAN	30	43.8 N	160.8 E	06	13	45	5 NM	02	1018.5	9.4	10.0	4	18	13	6	23
NORTH PACIFIC OCEAN		NOV.															
ENVIRONMENTAL BUOYS																	
EB 17	AMERICAN	23	52.0 N	156.0 W	15	05	M 42			990.6	2.7	4.8	10	21			
NORTH PACIFIC OCEAN		DEC.															
PRES EISENHOWER	AMERICAN	1	45.3 N	155.7 E	06	13	50	5 NM	02	1012.0	8.3	8.3	4	18	13	6	23
GREEN ECHO	LIBERIAN	2	40.0 N	150.2 E	18	32	M 60	200 YD	51	995.0	10.0	15.0	10	18			
UNIQUE FORTUNE	LIBERIAN	2	37.7 N	155.7 E	18	26	45	5 NM	03	999.8	19.0	18.0			29	X	29.5
VAN WARRIOR	LIBERIAN	2	39.2 N	148.3 E	12	36	45	1 NM	63	989.5	13.0	18.0					
AMER LANCER	AMERICAN	2	34.2 N	138.2 E	00	28	45	10 NM	03	1015.2	13.4	20.0	8	13			
ADRIAN MAERSK	DANISH	2	41.1 N	160.0 E	18	15	52	2 NM	63	999.2	12.0		10	32.5			
GREEN ECHO	LIBERIAN	3	38.3 N	148.5 E	06	30	M 45	1 NM	50	1010.0	12.0	20.0	14	19.5			
VAN WARRIOR	LIBERIAN	3	38.8 N	146.0 E	00	32	45	10 NM	03	1012.5	9.0	17.0					
UNIQUE FORTUNE	LIBERIAN	3	37.5 N	154.7 E	06	33	45	2 NM	03	1006.0	13.0	19.0			32	X	32.5
ARCO PRUDHOE BAY	AMERICAN	3	47.5 N	131.7 W	06	30	45	2 NM	07	1005.5	10.0	9.5					
AMER LANCER	AMERICAN	3	34.9 N	143.8 E	00	30	45	10 NM	02	1018.3	13.3	18.3	8	13			
ASIA BRAVERY	LIBERIAN	3	45.9 N	153.8 E	06	36	M 46	.25 NM	07	983.5	2.0	9.0	5	8	01	11	19.5
PACGLORY	LIBERIAN	3	43.1 N	153.7 E	00	33	47	1 NM	34	978.7	3.0	12.0	13	29.5			
PRES TRUMAN	AMERICAN	3	45.2 N	153.8 E	18	30	38	5 NM	85	999.0	- 1.0	2.2	6	16.5	30	8	32.5
SEALAND COMMERCE	AMERICAN	3	42.7 N	155.0 E	06	28	70	1 NM		985.5	6.2	3.3	9	32.5			
LONG BEACH	PANAMANIAN	4	37.1 N	165.9 E	06	27	M 44	5 NM	64	1007.0	11.5	10.0	13	16.5	27	>13	32.5
UNIQUE FORTUNE	LIBERIAN	4	37.6 N	152.7 E	00	34	40	5 NM	80	1017.0	12.0	18.0			35	X	36
ADRIAN MAERSK	DANISH	4	44.0 N	173.2 E	00	16	55	2 NM	02	993.0	8.3	8.0			16	>13	29.5
ARCO PRUDHOE BAY	AMERICAN	4	49.0 N	133.5 W	00	00	42	10 NM	02	1014.8	9.2	8.8	7	16.5	29	12	19.5
SEATRAIN VALLEY FORGE	GERMAN	4	45.3 N	102.5 W	00	06	44	2 NM	50	1012.3	6.2	5.0	12	21			
SEALAND FINANCE	AMERICAN	4	38.8 N	160.9 E	06	30	43	5 NM	15	1006.8	8.6	15.0	10	29.5			
SEALAND FINANCE	AMERICAN	5	43.2 N	172.7 E	05	32	45	10 NM	15	998.1	5.8	8.9	8	19.5			
PRES HARRISON	AMERICAN	5	32.7 N	173.5 E	00	28	45	10 NM	02	1009.0	16.1	20.0	5	10	28	9	14.5
PRES TAFT	AMERICAN	5	43.7 N	148.1 W	18	27	30	5 NM	03	1003.0	12.8	8.3	5	13	27	8	19.5
TOYOTA MARU #12	JAPANESE	5	42.7 N	146.0 W	18	25	M 30	.5 NM		1006.0	11.5	14.0	6	10	24	8	13
SEISHU MARU	JAPANESE	5	49.5 N	145.0 W	12	07	M 48	200 YD	65	997.0	3.0	5.5	3	6.5	07	6	16.5
SVENDBORG MAERSK	DANISH	6	20.2 N	136.7 E	00	21	48	2 NM	03	999.0	26.0	27.0	9	19.5			
OVERSEAS NATALIE	AMERICAN	6	53.2 N	136.1 W	00	07	48	5 NM	15	1002.0	4.5	6.7	4	5	08	8	10
ILLINOIS	AMERICAN	6	33.7 N	144.0 W	00	27	50	2 NM	03	1003.5	8.0	8.9	6	13	27	10	19.5
TOYOTA MARU #12	JAPANESE	6	43.1 N	145.2 W	00	26	M 47	1 NM		1007.5	9.0	11.0	8	26	27	12	32.5
WASHINGTON RAINBOW	JAPANESE	6	31.5 N	158.3 E	12	20	M 30	2 NM	03	998.0	21.0	22.0	7	11.5			
PRESIDENT MADISON	AMERICAN	7	48.5 N	125.3 W	00	27	M 50	5 NM	61	999.4	8.9	10.6	12	18			
ROSE	LIBERIAN	7	30.9 N	141.9 E	00	09	M 41	5 NM	01	1012.5	18.8	24.0					
OVERSEAS NATALIE	AMERICAN	7	49.3 N	128.5 W	00	30	48	5 NM	01	995.3	5.0	9.5	5	5			
TOYOTA MARU #12	JAPANESE	7	46.1 N	159.0 W	18	09	M 48	1 NM	63	989.0	8.0	8.0	6	16.5	10	8	19.5
PRES JOHNSON	AMERICAN	8	40.3 N	167.1 E	00	30	46	10 NM	02	1006.0	10.6	14.0	6	13			
QUEENS WAY BRIDGE	JAPANESE	8	37.8 N	164.2 W	18	23	M 48	2 NM	16	977.0	16.5	13.0	9	16.5	09	X	16.5
LING YUNG	CHINESE	8	54.0 N	161.4 W	18	08	M 41	5 NM	02	1009.7	5.0	5.5					
PRATTEEL	LIBERIAN	8	50.1 N	163.7 W	00	06	M 45	.25 NM	45	999.0	1.0	3.0	10	18			
BRINTON LYKES	AMERICAN	8	29.2 N	173.7 W	00	22	48	2 NM	07	1005.1	20.5	22.2	5	8	24	9	14.5
LING YUNG	CHINESE	9	54.4 N	165.5 W	00	08	M 44	5 NM	02	1008.4	4.0	3.0	4	8	08	7	14.5
CHESTNUT HILL	AMERICAN	9	35.4 N	165.9 W	00	26	46	2 NM	02	994.9	15.6	14.4	6	6.5	27	7	21
SEATRAIN PRINCETON	GERMAN	9	34.1 N	160.7 W	00	24	44	5 NM	00	998.7	18.9	17.4	7	14.5	23	10	18
ARCO PRUDHOE BAY	AMERICAN	9	54.4 N	148.4 W	18	08	42	5 NM	07	1018.2	0.0	3.3	8	11.5			
QUEENS WAY BRIDGE	JAPANESE	9	37.4 N	159.1 W	06	26	M 48	5 NM	01	993.5	14.5	13.0	10	16.5	23	12	29.5
PRESIDENT MADISON	AMERICAN	9	53.9 N	156.3 W	18	06	M 48	5 NM	02	1008.0	1.7	3.6	12	23	10	>13	26
PRES FILLMORE	AMERICAN	9	40.7 N	157.0 W	18	27	50	5 NM	02	991.5	10.6	12.7	14	19.5			
BRINTON LYKES	AMERICAN	10	30.8 N	170.4 E	06	23	60	5 NM	07	995.1	21.2	22.2	6	10	14	13	14.5
SEATRAIN PRINCETON	GERMAN	10	34.0 N	165.6 W	00	27	44	5 NM	03	1008.2	16.4	17.4	7	14.5	27	10	16.5
ARCO PRUDHOE BAY	AMERICAN	10	54.0 N	142.0 W	12	10	50	2 NM	07	993.0	- 0.1	4.4					
ANCO DUKE	BRITISH	10	37.0 N	177.5 E	21	29	60	< 50 YD	63	972.5	14.0	17.2	4	26			
PRES TAFT	AMERICAN	10	42.7 N	160.2 E	12	07	45	5 NM	02	990.0	3.0	6.7					
PRES FILLMORE	AMERICAN	10	41.0 N	154.4 W	00	26	45	5 NM	02	991.2	11.1	12.8	9	14.5	26	>13	19.5
WALTER RICE	AMERICAN	11	15.7 N	94.8 W	18	10	45	10 NM	02	1013.5	27.9	26.1	5	5	10	10	8
ARILD MAERSK	DANISH	11	36.3 N	162.5 E	06	30	45	5 NM	02	999.9	10.0		9	41			
BRINTON LYKES	AMERICAN	11	31.5 N	164.4 E	06	29	60	5 NM	07	1011.2	16.2	21.2	6	11.5	29	12	23
ANCO DUKE	BRITISH	11	37.0 N	177.4 E	00	29	45	5 NM	07	981.2	16.5	17.2	6	19.5			
ARCO PRUDHOE BAY	AMERICAN	11	51.8 N	142.0 W	00	05	45	2 NM	07	976.2	0.0	5.6	6	26	05	10	26
ANCO DUKE	BRITISH	12	35.6 N	179.2 E	06	28	50	5 NM	25	988.0	13.5	17.2	8	16.5	27	9	29.5
BRINTON LYKES	AMERICAN	12	31.9 N	160.0 E	06	30	50	10 NM	03	1018.5	14.4	23.3	5	11.5	30	12	23
PRES PIERCE	AMERICAN	12	38.1 N	166.0 E	00	32	45	5 NM	16	1002.4	6.1	15.0	12	13			
ROSE	LIBERIAN	12	33.3 N	174.4 E	06	27	M 45	5 NM	02	996.5	14.0	19.0					
SEATRAIN PRINCETON	GERMAN	12	33.6 N	178.2 W	12	27	45	5 NM	13	997.5	16.4	18.0	8	19.5	27	X	23
PRES MCKINLEY	AMERICAN	12	36.1 N	167.2 E	06	27	44	10 NM	02	996.3	11.1	17.8	6	10	29	10	21
ARCO PRUDHOE BAY	AMERICAN	12	49.6 N	131.9 W	18	20	45	2 NM	07	1001.2	14.0	10.0	7	14.5			
SEATRAIN PRINCETON	GERMAN	13	33.1 N	178.8 W	00	26	45	10 NM	03	998.5	17.1	17.0	8	16.5	26	10	23
OCEANOGRAPHER	AMERICAN	13	44.2 N	125.0 W	18	21	M 43	.25 NM	61	1003.7	13.4	13.3	4	6.5	22	9	8
ORIENTAL SOVEREIGN	LIBERIAN	14	52.7 N	147.1 W	00	34	M 55	1 NM	26	964.0	1.5	6.0	7	13			
PRES EISENHOWER	AMERICAN	14	41.3 N	136.8 W	06	23	41	5 NM	50	997.0	15.6	14.4	5	16.5	23	6	19.5
PHILADELPHIA	AMERICAN	14	56.3 N	141.8 W	12	30	5	5 NM	82	952.0	4.4	4.4	4	16.5	12	< 6	32.5
AMERICA MARU	JAPANESE	14	39.1 N	153.0 W	00	30	M 41	5 NM	02	1006.5	9.0	11.8	4	6.5	32	7	11.5
MAINE	AMERICAN	14	39.1 N	141.6 W	18	28	50	1 NM		1001.0	12.2	12.3	5	6.5	27	8	13
BRINTON LYKES	AMERICAN	14	33.5 N	146.7 E	00	36	45	10 NM	62	1022.7	15.7	22.2	3	5	36	8	11.5
SANSINENA II	AMERICAN	15	58.3 N	149.6 W	06	05	45	5 NM	07	996.8	2.5	4.5	2	10	09	6	21
PHILADELPHIA	AMERICAN	15	55.2 N	137.1 W	00	18	46	5 NM	88	980.0	2.2	7.2	4	16.5	18	6	32.5
MAINE	AMERICAN	15	38.7 N	138.8 W	00	28	45	5 NM	03	1009.5	12.0	13.9	5	8	28	8	11.5
CALIFORNIAN	AMERICAN	15	44.8 N	128.8 W	18	29	36	10 NM	01	1003.5	8.9	9.4	4	10	27	10	26
EASTERN JADE	LIBERIAN	15	30.0 N	165.5 E	18	05	M 45	1 NM	63	1014.0	15.0	21.0	XX	32.5			
JAPAN ACE	JAPANESE	17	36.5 N	130.6 W	00	25	M 41	10 NM	02	1002.5	18.0	14.0	7	14.5			
MIKI MARU	JAPANESE	18	40.4 N	156.4 W	18	33	M 45	5 NM	64	1015.0	7.5	11.0	6	6.5	31	10	16.5
ASIAN ASSURANCE	LIBERIAN	18	53.7 N	155.9 W	12	32	M 42	2 NM	02	1015.5	0.0	4.0	10	6.5			
QUEENS WAY BRIDGE	JAPANESE	19	37.3 N	135.5 W	06	16	M 47	5 NM	03	1006.0	15.5	16.5	12	18			

Vessel	Nationality	Date	Position of Ship		Time GMT	Wind			Visibility n. mi.	Present Weather code	Pressure mb.	Temperature °C		Sea Waves*		Swell Waves		
			Lat. deg.	Long. deg.		Dir. 10°	Speed kt.					Air	Sea	Period sec.	Height ft.	Dir. 10°	Period sec.	Height ft.
NORTH PACIFIC OCEAN		DEC.																
ROSE	LIBERIAN	19	35.2 N	136.8 W	18	18	M	45	2	NH	03	1004.0	11.0	19.0			14	X	29.5
SEATRAIN LEXINGTON	GERMAN	19	34.3 N	136.1 W	00	34		50	5	NH	14	1017.5	11.2	15.5	9	23	XX	X	16.5
PRES FILLMORE	AMERICAN	19	39.3 N	153.2 W	06	36		45	5	NH	19	1019.3	7.2	12.8	9	11.5	31	>13	24.5
AVILA	AMERICAN	19	25.1 N	148.7 W	18	34		45	10	NH	02	1015.0	17.2	22.2	9	24.5			
EXXON NEW ORLEANS	AMERICAN	19	44.9 N	129.9 W	18	13		45	5	NH	02	1015.0	11.9	11.2	XX	8	14	11	11.5
TOYOTA MARU # 10	JAPANESE	19	37.0 N	155.6 W	06	36	M	35	2	NH	02	1021.5	11.0	14.0	XX	13	35	11	32.5
SEATRAIN VALLEY FORGE	GERMAN	20	37.3 N	167.0 E	00	32		52	5	NH	61	996.1	11.0	13.0	5	8	XX	X	11.5
ROSE	LIBERIAN	20	38.2 N	139.2 W	00	14	M	45	2	NH	03	1000.5	16.5	18.0			18	X	29.5
PRES EISENHOWER	AMERICAN	20	37.9 N	177.4 W	00	18		41	2	NH	50	1010.0	15.0	13.9	3	13	18	6	23
DAVID STARR JORDAN	AMERICAN	20	34.2 N	120.3 W	18	10	M	45	5	NH	03	1018.5	15.0	15.6			10	4	6.5
CALIFORNIAN	AMERICAN	20	28.2 N	144.1 W	06	32		41	10	NH	21	1007.0	13.6	20.6	3	16	32	9	26
EXXON NEW ORLEANS	AMERICAN	20	41.6 N	127.0 W	18	15		35	5	NH	07	1005.6	13.4	13.4	XX	26	16	10	35.5
HAWAIIAN ENTERPRISE	AMERICAN	20	30.8 N	131.5 W	06	15		45	5	NH	60	997.3	17.8	18.9	6	14.5			
MATSONIA	AMERICAN	20	26.4 N	146.8 W	06	35		41	5	NH	18	1010.8	15.0	21.7	4	6.5	31	7	11.5
HAWAIIAN MONARCH	AMERICAN	20	35.7 N	130.6 W	06	13		45	5	NH	64	998.0	16.1	17.8	10	19.5			
PRES EISENHOWER	AMERICAN	21	34.9 N	169.0 E	18	20		48	5	NH	02	1007.0	16.7	17.2	5	10	20	8	29.5
DANWOOD ICE	DANISH	21	28.4 N	114.7 W	00	05	M	42	> 25	NH	02	1019.0	20.0	17.5	3	10			
ARCO FAIRBANKS	AMERICAN	21	40.3 N	126.0 W	06	14	M	00	2	NH	07	1003.2	15.0	11.2			14	12	19.5
JAPAN RAINBOW	JAPANESE	21	53.9 N	173.3 W	18	10	M	45	5	NH	09	987.0	3.0	4.0	5	5			
PRES JEFFERSON	AMERICAN	21	42.9 N	179.2 E	06	30		45	10	NH	01	1005.8	7.8	9.4	6	13	30	< 6	24.5
PRES FILLMORE	AMERICAN	21	40.4 N	177.1 W	12	27		45	5	NH	02	1012.5	8.9	12.2	7	10	29	X	19.5
ROSE CITY	AMERICAN	21	36.3 N	146.0 W	00	36		55	10	NH	27	1002.5	10.5	11.1	XX	11.5	36	12	24.5
PACIFIC ARROW	JAPANESE	21	35.4 N	123.2 W	00	14	M	43	5	NH	07	1008.5	15.5	16.5	4	8	14	7	11.5
JAPAN RAINBOW	JAPANESE	22	54.5 N	176.7 W	06	23	M	45	5	NH	05	983.0	3.0	3.0	5	5			
LONG BEACH	AMERICAN	22	14.4 N	95.7 W	12	36		40	5	NH	07	1013.0	24.4	29.7	9	32.5			
SEALAND FINANCE	AMERICAN	22	53.4 N	177.4 W	00	23		50	5	NH	02	976.0	4.7	2.7	5	10	23	6	13
SEATRAIN CONCORD	FRENCH	22	39.4 N	160.5 W	00	33	M	41	5	NH	02	1010.5	13.0	11.5	3	5			
PRES FILLMORE	AMERICAN	22	40.2 N	178.3 E	00	20		45	5	NH	51	1006.4	12.8	13.9	7	10	32	7	19.5
ROSE CITY	AMERICAN	22	30.8 N	147.3 W	00	31		45	5	NH	19	1010.0	17.7	14.4		11.5	34	>13	23
PRES FILLMORE	AMERICAN	24	39.3 N	159.4 E	00	32		47	2	NH	64	1013.5	4.4	14.4	8	14.5	32	12	24.5
EURYMEDON	LIBERIAN	25	40.4 N	163.3 E	18	19	M	55	5	NH	02	983.0	12.0	14.0					
GREEN ECHO	LIBERIAN	25	41.3 N	169.6 E	18	21	M	45	.5	NH	51	1003.0	10.0	11.0	9	14.5			
ILLINOIS	AMERICAN	25	34.9 N	143.9 E	12	26		45	10	NH	01	1000.8	18.3	18.3	4	6.5	06	< 6	11.5
VAN WARRIOR	LIBERIAN	25	39.0 N	163.0 E	18	22		60	.5	NH	53	986.0	15.0	15.0					
SEALAND MC LEAN	AMERICAN	25	40.9 N	168.0 E	18	18		50	10	NH	02	997.8	10.6	11.2	8	14.5	16	10	18
SEATRAIN LEXINGTON	GERMAN	25	34.5 N	149.4 E	06	20		50	.25	NH	69	999.0	18.2	18.8	6	13	XX	X	8
CORAL ARCADIA		26	30.1 N	175.1 E	06	14	M	52	.5	NH	82	982.0	3.0	3.0	10	19.5			
EURYMEDON	LIBERIAN	26	40.8 N	165.0 E	00	20	M	50	5	NH	02	984.0	9.0	12.0					
GREEN ECHO	LIBERIAN	26	41.7 N	170.9 E	00	18	M	75	.5	NH	51	992.0	12.0	10.0	11	18			
SEALAND MC LEAN	AMERICAN	26	43.6 N	179.9 E	18	19		55	2	NH	61	995.8	10.6	7.2	8	26	17	12	26
PRES TRUMAN	AMERICAN	26	36.5 N	160.9 E	00	21		45	2	NH	61	992.2	16.7	15.6	3	8	21	9	19.5
AMER LEGION	AMERICAN	26	37.1 N	177.6 E	12	20		45	5	NH	02	1013.9	14.4	15.0	3	6.5	20	< 6	13
EASTERN PACIFIC	JAPANESE	26	46.3 N	180.0 E	18	29	M	50	2	NH	15	998.5	- 1.0	4.0	8	11.5	29	>13	24.5
ASIAN ASSURANCE	LIBERIAN	26	40.8 N	146.3 E	06	28	M	42	30	VD	84	998.5		12.0	14	13	29	>13	19.5
JAPAN RAINBOW	JAPANESE	26	46.2 N	158.7 E	06	32	M	41	2	NH	09	981.0	- 2.0	2.0	5	6.5			
MONTIGNY	LIBERIAN	26	53.0 N	173.1 W	20	15	M	61	.5	NH	10	982.5	4.0	2.0	9	24.5	13	12	34.5
TRIUMPH	PANAMANIAN	26	46.4 N	158.1 E	06	32	M	66	.25	NH	90	968.0	0.0	6.0		29.5	32	< 6	32.5
VAN WARRIOR	LIBERIAN	26	39.9 N	164.1 E	00	19		45	2	NH	50	986.0	13.3	15.0					
SEALAND MC LEAN	AMERICAN	27	44.6 N	176.2 W	00	18		45	2	NH	02	998.2	9.4	7.8	10	19.5	25	>13	16.5
MONTIGNY	LIBERIAN	27	52.9 N	173.9 W	00	15	M	50	.5	NH	10	979.0	7.0	2.0	9	24.5	13	12	36
ILLINOIS	AMERICAN	27	38.0 N	140.3 E	00	29		48	10	NH	01	1009.0	13.9	17.2	4	10	30	7	24.5
SEALAND EXCHANGE	AMERICAN	28	52.3 N	164.3 W	06	23		41	10	NH	02	999.7	3.4	2.6	8	6.5	23	7	13
VAN WARRIOR	LIBERIAN	28	43.1 N	174.8 W	18	18		45	5	NH	03	1006.0	11.0	9.0					
VAN WARRIOR	LIBERIAN	29	44.4 N	169.6 W	12	18		50	5	NH	03	1002.0	10.0	6.0					
TRIUMPH	PANAMANIAN	29	36.9 N	143.2 E	19	23	M	49	2	NH	02	1011.5	14.0	21.0	7	29.5	23	6	32.5
GREEN ECHO	LIBERIAN	29	49.8 N	166.0 W	06	18	M	45	2	NH	02	1007.0	6.0	4.0	10	16.5			
GLADIOLUS	LIBERIAN	29	39.5 N	175.4 W	06	19	M	42	2	NH	03	1007.0	14.0	10.0	7	16.5			
KOREA PHOENIX	SINGAPORE	30	38.3 N	138.0 E	17	07	M	42	5	NH	03	1018.0	10.0		4	6.5			
ORIENTAL SOVEREIGN	LIBERIAN	30	42.9 N	155.9 E	18	32	M	48	10	NH	83	1013.0	1.0	3.0	8	14.5	32	12	19.5
EASTERN PACIFIC	JAPANESE	30	39.2 N	144.5 E	06	33	M	42	10	NH	02	1001.8	7.0	13.0	5	6.5	32	10	18.5
KOREA PHOENIX	SINGAPORE	31	39.9 N	137.0 E	05	07	M	42	5	NH	03	1011.0	9.0		4	6.5			
VAN WARRIOR	LIBERIAN	31	45.8 N	176.8 W	06	12		45	1	NH		991.0	10.0	3.0					
SEALAND EXCHANGE	AMERICAN	31	42.0 N	164.0 E	00	29		48	10	NH	18	1008.5	4.5	6.6	7	19.5	29	>13	31
ARCTIC TOKYO	LIBERIAN	31	50.7 N	161.5 E	18	27	M	48	2	NH	26	1016.0	- 4.0	3.0	8	11.5			
NORTH PACIFIC OCEAN		DEC.																	
ENVIRONMENTAL BUOYS																			
EB 16	AMERICAN	15	42.5 N	130.0 W	09	29	M	48				997.3	10.3		10	24.5			
EB 20	AMERICAN	14	41.1 N	137.8 W	21	23	M	44				988.0	12.3		8	18			
EB 20	AMERICAN	15	41.1 N	137.8 W	00	29	M	45				1001.3	9.1		8	21			
EB 21	AMERICAN	15	46.0 N	131.0 W	12	31	M	46				999.3	5.0	10.4	8	18			
EB 45	AMERICAN	6	60.2 N	146.8 W	12	02	M	41				1019.5	- 1.5	5.8					
EB 72	AMERICAN	14	57.1 N	151.7 W	18	33	M	44				956.1	- 2.7	4.2	8	23			

\+ Direction for sea waves same as wind direction
X Direction or period of waves indeterminate
M Measured wind

NOTE: The observations are selected from those with winds ≥ 35 kn or waves ≥ 25 ft from May through August (≥ 41 kn or ≥ 33 ft, September through April). In cases where a ship reported more than one observation a day with such values, the one with the highest wind speed was selected.

Rough Log, North Atlantic Weather

February and March 1978

ROUGH LOG, FEBRUARY 1978--The paths traced by the low-pressure centers this month differed radically from climatology. There were fewer storms than normal over the United States, but a nearly normal number over the seas. There were more storms than usual over the Mediterranean Sea, particularly the eastern half. Most of the LOWs formed over water rather than tracking over the land. The primary average track was from Cape Hatteras to 45°N, 40°W, where the storms dissipated or turned sharply northnortheastward. Several storms tracked onto the continent.

The Icelandic Low at 991 mb near 49°N, 36°W, was 12 mb lower than normal and 600 mi south of its usual location. The Azores High was 1019 mb near 24°N, 27°W. This was 1 mb lower than normal and 300 mi to the southeast. A large 1029-mb High was firmly entrenched over central Canada and affected both North Atlantic and North Pacific storms.

The deep LOW and abnormal position produced a -19 mb anomaly center near 48°N, 35°W. The ocean north of 20°N was influenced by this large anomaly. There were three positive anomaly centers across the north country--a +9 mb over central Canada, a +13 mb over northern Baffin Bay, and a +14 mb near Scoresby Sound.

The upper air circulation was influenced likewise by the misplaced pressure/height centers. A low center to match the climatological center was over the Queen Elizabeth Islands, but the main circulation center was near 50°N, 40°W. The surface High over Canada was reflected in the upper air by a sharp ridge over the Rocky Mountains. A weak ridge was evident over the European west coast. There was a large negative anomaly over the central ocean and a large positive anomaly over northern Canada.

Extratropical Cyclones--A large area of weak low pressure was centered south of Newfoundland on the 1st. By 1200 there were three centers, with the one of interest near 37°N, 60°W. At 0000 on the 2d, the ESCHERSHEIM was about 370 mi southwest of the center battling 60-kn winds. Far to the north just north of St. John's and one of the other centers two U.S.S.R. ships fought 50-kn plus winds. At 0600 the GARINDA (38°N, 49°W) had 64-kn winds, and at 1200 the EXPORT COMMERCE (38°N, 42°W) was battling squalls and 31-ft swells.

At 1200 on the 3d the storm was 974 mb centered near 54°N, 35°W (fig. 54). The IDEFJORD about 250 mi southeast of the center was fighting 60-kn winds and 43-ft seas. About 350 mi to the southwest the C.P. DISCOVERER also fought 60-kn winds with 33-ft seas and 39-ft swells. The C.P. VOYAGEUR reported at 1138 on the 3d that a 20-ft container was lost overboard while 1,000 mi east of St. John's, Newfoundland. Six hours later a ship (50°N, 35°W) estimated 60-kn winds, 33-ft seas, and 49-ft swells. The IDEFJORD was still wallowing in 43-ft seas on the 4th, but the winds had dropped to 50 kn. As the 973-mb LOW moved north of OWS Lima on the 4th, she had 23-ft

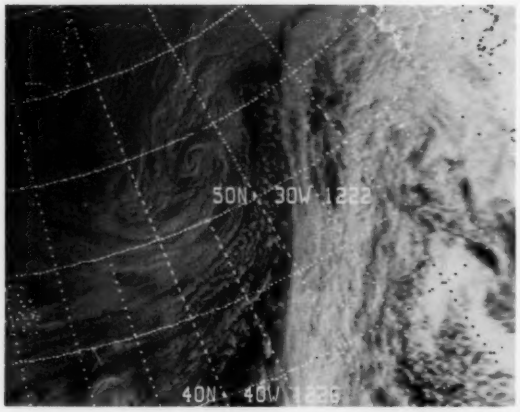

Figure 54.--This satellite picture verifies the position of the storm from the analysis of ship reports.

waves, and two ships as far away as 900 mi to the south-southwest had 25-ft waves. The DISCOVERER reported at 1353 on the 4th that five 20-ft and four 40-ft containers were lost overboard. The waves at Lima dropped to 20 ft on the 5th as the storm weakened south of Iceland. On the 6th it dissipated on the coast of Iceland.

Monster of the Month--This was a Cape Hatteras storm. A small 1012-mb circulation was analyzed on the 0000 chart of the 6th with the aid of buoy 41002 (fig. 55). At 1800 the SOLIMOES (33°N, 77°W) had northerly 60-kn winds off Wilmington. The LOW was following the coast, and the northeasterly circulation was bringing more snow to the embattled northeast as far west as the Great Lakes. On the 6th the storm brought 58-kn winds to the Meteorological Observatory in Blue Hill, Mass., 69-kn winds to Boston, Mass., and 114-kn easterly winds to the Mt. Washington Observatory in New Hampshire, which is 6,262 ft above sea level. The strong onshore winds caused heavy beach and shore erosion with coastal flooding from New York

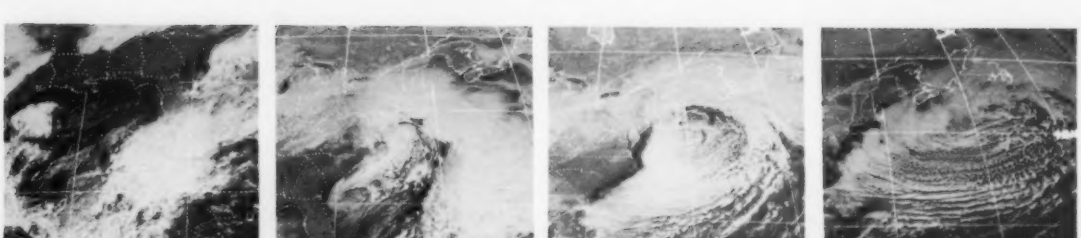

Figure 55.--This series of four SMS satellite images at 1700 on February 5 through 8 (left to right) shows the path and intensification of this vicious storm as it moved along the coast.

Figure 56.--The houses along the beach at Ocean Beach, N.Y., were shattered by high tides and winds tilt toward the water. Prior to the storm, there had been about 100 ft of beach in front of the houses. Wide World Photo.

Figure 57.--The PETER STUYVESANT, a restuarant ship that was docked on the Boston waterfront, lies on its side and is sinking. Wide World Photo.

Figure 58.--The Massachusetts coast near Scituate was one of the hardest hit areas where 100 mi/h winds resulted in the waves breaking over the top of the sea wall. American Red Cross Photo by Philip Gibson.

northward (figs. 56 to 60). Cape Cod measured 80-kn winds. The entire northeastern United States was paralyzed with deep snow and drifts. Twenty to 30 inches of new snow was common and blowing into huge drifts. Tides were running 2 to 6 ft above normal. Record cold temperatures reached into Florida as northerly winds plunged southward west of the LOW.

A new 24-hr snowfall record of 22 in was recorded at Boston. New York City had a total of 17 in for the heaviest snow in 30 yr. On Route 128 near Canton, Mass., some 2,500 stranded vehicles including 500

Figure 59.--Although there was clearing weather on the 8th, heavy surf continued to pound the beachfront property at Peggotty Beach in Scituate, Mass. Wide World Photo.

Figure 60.--These houses at Center Hill, Mass., south of Nantasket Beach were severely damaged, much of which is hidden by shadows. The house at the lower center had been completely destroyed. Photo by Bob Clark and processed by Imagery Processing Laboratory, NOS.

trucks clogged an 8-mi stretch of the highway. A statewide ban on nonemergency driving was imposed in Connecticut and Massachusetts. National Guard and Federal troops aided in rescue and patrolling operations. Airports were closed and bus and rail traffic came to a virtual standstill.

At 0000 on the 7th the YOUNG AMERICA (39°N, 65°W) was east of the 984-mb center and sailing into 65-kn easterly winds with 20-ft waves. A ship and a Coast Guard cutter off Cape Cod had 50- and 55-kn winds. At 1200 a German ship near 38°N, 62°W, reported 72-kn winds and 26-ft seas and swells. Other ships south and east of the center had 50- to 60-kn winds and 20- to 25-ft waves. The 38,889-ton Greek tanker GLOBAL HOPE was blown aground at Massachusetts Bay. Five men aboard a pilot boat sent to aid the tanker were missing and are feared lost.

On the 8th the storm was moving eastward but still bringing snow and winds to the northern New England coast. The H1070 had 50-kn winds, 30-ft seas, and 36-ft swells off Cape Sable. Several other ships had winds in the 50-kn category with seas to 25 ft. At 1200 on the 9th the 980-mb storm was east of Newfoundland and turning northward. The ATLANTIC CONVEYOR and ALMERIA STAR were southwest and southeast of the center, respectively, with 30-ft swells.

On the 10th the storm was moving westward and crossed the Labrador coast on the 11th. It then turned southward and eastward to disappear over the Gaspe Peninsula on the 13th.

A LOW out of the Gulf of Mexico moved across Florida on the 9th. It tracked east-southeastward, and a ship found 50-kn winds 300 mi south of the center on the 10th. Later in the day the storm developed multiple

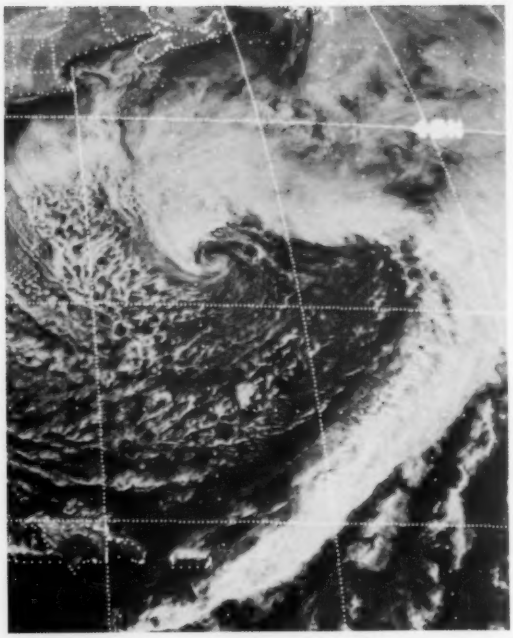

Figure 61.--This SMS image for 1700 on the 11th shows this alternate "Monster of the Month" centered near 32°N, 64°W.

centers along the track and a trough that stretched southwestward. On the 1200 chart of the 11th, a center was analyzed near 32°N, 67°W (fig. 61). By midday on the 12th it was obvious that this was developing into the primary storm as the central pressure plunged to 970 mb. Among the half a dozen ships that reported winds of 50 kn or more, the ones with the highest seas and swells were in the southwest quadrant. They were the BISCHOFSTOR (39 ft), ERLANGEN (36 ft), and MORMACSEA (30 ft).

On the 13th the EXPORT LEADER and DEDA were within 50 mi of each other near 39°N, 57°W, with 25- to 30-ft seas and swells. At 1200 the storm was whirling about 42°N, 47°W, at 956 mb. There were now eight reports around the storm of winds of 50 kn or greater. The highest was 88 kn with 26-ft waves by the BISCHOFSTOR (30°N, 60°W) about 1,000 mi southwest of the storm's center. Other ships including the SOLON TURMAN were tossed by 33-ft swells. The 7,046-ton Pakistani cargo vessel AL KULSUM bound for New York experienced heavy weather 1,300 mi to the southeast. Late on the 13th, a second LOW center formed in the southwest quadrant. This tightened the pressure gradient south of the centers. The gradient was also tightening to the north as a 1046-mb HIGH sat over Baffin Island. Ships north of the center found 50- to 60-kn northeasterly winds and waves to 30 ft.

Late on the 13th the HIGH was retreating westward as the LOWs moved northward. On the 14th winds of 70 kn were reported both north and south of the storm's center. The British tanker IRVING STREAM

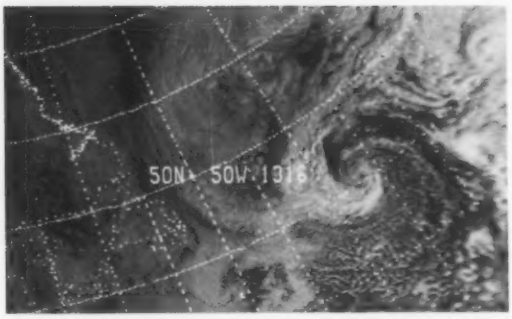

Figure 62.--This is how the storm appeared from space when the USNS COMET encountered 91-kn winds.

reported two bollards torn off at a wharf in St. John's, Newfoundland, with 50-kn northeasterly winds and freak undertow early on the 14th. The lines of a cargo schooner parted and it collided with a fishing vessel which became fouled in another ship's lines. On the 15th (fig. 62) the USNS COMET reported 91-kn winds east of the two centers which were approaching each other to merge on the 16th. The DART AMERICA was hove to at 1000 on the 15th when the pressure dropped to a minimum of 950 mb. The winds in the ship's log were northwesterly at force 11-12. A note on the barogram (fig. 63) indicated the winds reached 85 kn near 45.5°N, 38°W. The vessel was pitching and rolling heavily in very heavy seas and swells and shipping water and spray overall. The NORTHERN was off Kap Farvel with 39-ft seas. The 5,000-ton German tanker ALCHIMIST ran aground in rough seas 30 mi north of Lisbon on the 16th. Helicopters rescued 7 of the 13 men in the crew. The remainder stayed aboard. A Portuguese Navy frigate stood nearby, but its rescue operations were hampered by 12-ft waves. In the meantime another low center from the vicinity of Cape Hatteras was racing eastward under zonal flow south of the main LOW. It was creating gale-force winds and swells up to 25 ft. The primary LOW was stationary near 49°N, 38°W, until the 18th. Winds in the 50-

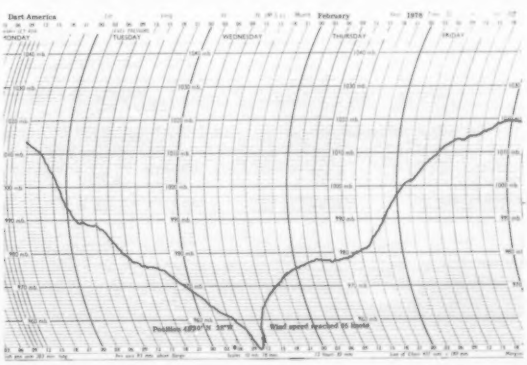

Figure 63.--A copy of the barogram from the DART AMERICA shows the depth of this extratropical storm which dwarfs many tropical storms.

kn range were blowing in all quadrants with isolated reports of waves up to 33 ft. Most were in the 20-ft range.

By the 18th the peripheral LOW had curved around and into the center of the circulation, and the old LOW started to slowly drift eastward. The NEW ZEALAND STAR was pounded by 33-ft waves near 37°N, 36°W. On the 19th the new center became the primary circulation center, but this mattered little to ships fighting the high winds and waves. On the 20th the LOW began moving westward and weakened rapidly over the Labrador Sea. In the meantime all was not quiet on the eastern front. On the 18th the front was approaching the European coast, and a LOW formed at the point of occlusion south of Ireland. Snow and ice paralyzed large areas of northwestern Europe. One of the worst snowfalls in 30 yr hit southwest England with up to 18 in. Gales drifted the snow into 20-ft drifts. Roads and railroads were blocked and thousands were without electricity as powerlines were downed. At least 100,000 people were without water because of power loss, and 600 schools were closed. In northern France the extreme cold killed two people. A quarter of a million people were without electricity as powerlines and concrete pylons snapped in the cold. Temperatures dropped to -15°C. In Paris the International Airport was closed owing to snow and ice on the runway. About 2.5 in of snow fell on the city, the third snow in a week where normally only about two occur in a year. In Denmark the mercury fell to -25°C. Stockholm was hit by 2 ft of snow, and hurricane-force winds lashed the west coast of Norway. Nine fishermen were missing after their ship sank late on the 18th. Northern Poland suffered blizzard conditions. Thick ice covered the bays of the Baltic Sea coast, where icebreakers were required to keep ships moving.

Another storm was moving into the circulation from the southwest. The original LOW became stationary near Anticosta Island on the 23d. It was very stubborn and survived to move eastward again, but it disappeared east of Newfoundland on the 27th.

There was a series of three frontal waves on a weak front that paralleled the U.S. East Coast on the 18th. The center one survived to become another severe storm. The LONG BEACH was west of the 984-mb center (41°N, 56°W) with 50-kn winds on the 20th. At 0000 on the 21st, the MUENCHEN was near 40°N, 45°W, about 300 mi southwest of the 969-mb center, with 60-kn winds and 39-ft seas. At 0600 the DORDRECHT (41°N, 41°W) had 52-kn winds and 31-ft seas and swells on her stern. At 1200 the SEALAND GALLOWAY was 1 of 10 ships that reported winds of 50 kn over or around the storm. Her report of 50-kn winds and 41-ft seas was from 41°N, 35°W, directly south of the 970-mb storm. There were reports of waves of over 20 ft as far as 900 mi from the center around the southern hemisphere of the storm. These continued into the 22d. At 1200 the BORNHEIM was near the Azores Islands with 60-kn winds and 41-ft seas and swells (fig. 64).

Another low center had formed north of the original one and on the 23d became the primary storm and tracked northward. This brought strong southeasterly winds to the North Sea. Winds of 50 to 60 kn and seas to 30 ft pounded shipping and platforms. This lasted into the 24th, when the new storm also disappeared from the analysis.

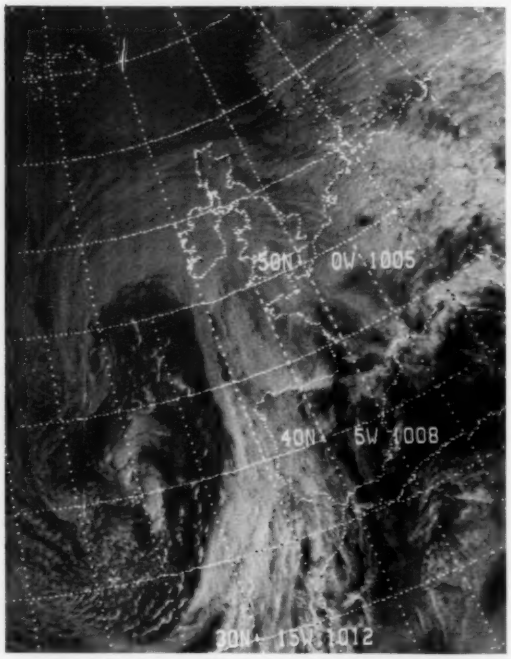

Figure 64.--The double centers of this storm show clearly in this NOAA image. The centers were near 48°N, 21°W, and 41°N, 20°W, at this time on the 22d. The prevailing westerly winds near the Azores have built up giant swells.

The frozen tundra of Canada north of Lake Winnipeg produced this LOW. In 2 days it plunged south to southern Missouri where it turned eastward. The center crossed the Carolina coast about 0300 on the 22d. At 1800 the USNS COMET was near 32°N, 75°W, with 50-kn winds and 20-ft waves. At 0000 on the 23d the 980-mb LOW was near 38°N, 59°W. The GREEN HARBOUR (35°N, 57°W) fought 55-kn winds and 26-ft waves on her bow. At 1200 the OLIVIA MAERSK at 36°N, 53°W, had 60-kn winds and 23-ft swells on her bow while about 400 mi south of the storm's center.

By 1200 on the 24th, the storm was 944 mb near 48°N, 37°W. The BRUNSHAUSEN (36°N, 37°W) battled 52-kn winds and 49-ft swells. At 1800 two ships, the ACAVUS (45°N, 36°W) and CHESHIRE (43°N, 38°W), had hurricane-force 70-kn winds. The latter had 41-ft seas and 66-ft swells while the former had only 26-ft seas and 49-ft swells. Six hours later at 0000 on the 25th the STEPHANITOR near 42°N, 37°W, or about 500 mi southwest of the 942-mb center, was sailing with 52-kn winds, 33-ft seas, and 46-ft swells on her stern. Later in the day the ZEALANDIC, which was near 41°N, 20°W, reported 57-ft swells on three observations. The MORETON BAY (43°N, 21°W) joined in with 59-ft swells on the 1800 observation. Winds of 50 kn and waves over 30 ft continued through the 26th.

Minor LOWs and troughs were moving around the

southern part of the circulation as the primary LOW split into several centers. The central pressure was rising and the winds and seas were decreasing. On the 27th one of the new LOWs became the primary center which deteriorated on the 28th, but another center carried the now minor storm into the Norwegian Sea.

A weak, flat high-pressure area was centered over the Ohio River Valley on the 27th. The large low-pressure area described above was over the eastern ocean and breaking down with minor LOWs and troughs between. A weak 1007-mb LOW was analyzed over Maine and New Brunswick. It moved southeastward and intensified over the warmer water. By 0000 on the 28th it was 980 mb near 42°N, 52°W. The CARCHESTER was within 2 mb of the center with 45-kn winds. As the LOW turned northeastward, the CHESHIRE near 40°N, 52°W, was headed into 45-kn winds and 30-ft swells. On March 1 the LOW had deepened to only 976 mb, but its area of cyclonic influence had expanded many times. The ILLYRIC was in the vicinity of 38°N, 42°W, with 50-kn winds on her port quarter. The seas were 33 ft and swells 21 ft. At 1800 the seas were 33 ft and swells 41 ft. On the 2d the highest values on the communication circuits were 60 kn and 21 ft. Late in the day the LOW split into two centers, and on the 3d these disappeared as another major storm extended its influence.

Casualties--The British barge FEDERAL 400-2 carrying the jack-up drilling rig ORION went aground in high winds and waves on Guernsey in the Channel Islands on the 2d. The ORION was floated free of the barge on the 27th and towed to Cherbourg. The tanker VENPET under tow Cape Town for Japan put into Algoa Bay on the 12th because of heavy weather damage to the already damaged ship. The British hopper barge W.D. SEAWAY was damaged at St. George's, Bermuda, when sudden 70- to 90-kn winds struck. The 5,897-ton Pakistani SUNDERBANS put into Gibralter on the 16th with leaks in shellplating. The vessel had reportedly suffered heavy weather earlier on voyage Montreal to Charleston.

A news report from Havana on the 24th indicated that an unidentified new ship being delivered from the United States to Costa Rica ran aground on coral reefs on the northwest coast of Cuba during severe storms on the 22d. The 20-man crew was taken off by a fishing vessel. There were no injuries. The 20,515-ton Greek ELOCEAN arrived La Pallice, France, on the 28th with heavy weather damage.

The Panamanian cargo vessel PHANTOM was surveyed at Norfolk for alleged heavy weather damage. The American cargo vessel MERRIMAC (15,995 tons) encountered heavy weather off Virginia that damaged dump valves. The German cargo vessel ELISABETH ROTH encountered heavy weather on a voyage from the United States to Saudi Arabia. The container vessel TRANS EUROPA lost containers overboard on a voyage for U.S. East Coast ports.

ROUGH LOG, MARCH 1978--The primary cyclone-center track across the ocean was from Newfoundland to the Faeroe Islands. This was farther south than the climatological track for this month. It normally extends from Hamilton Inlet to Iceland with another from Newfoundland to midocean. The paths which feed into the actual Newfoundland gate were also different. There was a three-storm track up the Atlantic coast with several more farther east at sea. Two paths came across the northern United States and southern Canada--one across the Great Lakes and the other across James Bay. These two joined over Newfoundland and, of course, there were mavericks that branched off. There was no specific pattern to the storm centers that penetrated Europe. There were two centers over the eastern Mediterranean Sea.

The monthly mean sea level pressure pattern helps explain the paths of the cyclone centers. The Icelandic Low was near 61°N, 26°W, about 500 mi east-northeast of its normal location, and 15 mb lower in pressure. The Azores High was 8 mb higher in pressure near 36°N, 22°W, and at least 800 mi northeast of its normal position.

These pressure variations and locations produced some large anomaly centers. There was a -16 mb near 60°N, 25°W, a -13 mb over the Greenland icecap, and a +10 mb near 37°N, 20°W. Over the eastern United States the pressure was slightly higher over the northern plains and south of the Great Lakes.

In the upper air at the 700-mb surface the primary center of circulation was near its normal position over Baffin Island, but there was an anomalous trough and LOW above the surface Icelandic Low. There is normally a slight ridging near Iceland that extends southward approximating longitude 5°W. This ridging was wiped out except along the coast of Portugal. From Newfoundland to Florida the constant pressure surface heights were nearly identical with climatology.

Extratropical Cyclones--This frontal wave was analyzed on the first chart of the month off Charleston, S.C. There were seven ship reports in the area. By 1200 on the 2d the LOW was 975 mb near 41°N, 54°W. At 1800 the CRANIA had winds over 50 kn south of the storm, and the LETCHWORTH had following 33-ft swells in the far southwestern quadrant at 35°N, 70°W. On the 3d there were many 50-kn and over wind reports in all quadrants. At 1200 the CLYTONEUS and POST CHAMPION took the honors with 40-ft swell waves along 40°N between 49°W and 53°W (fig. 65). At

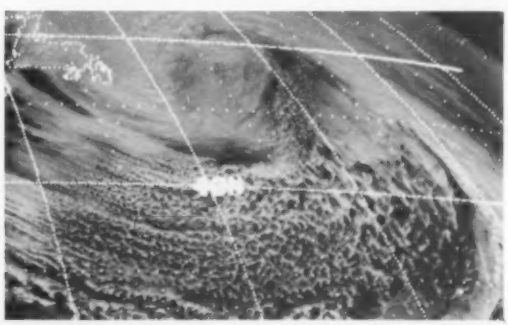

Figure 65.--The high swell waves were found with the unstable cold air over the warmer water as indicated by the cumulus clouds.

1800 the DART ATLANTIC (43°N, 46°W) was due south of the 948-mb center with 65-kn winds and 33-ft waves, which increased to 75 kn and 40 ft at 0000 on the 4th. The POST CHAMPION now had 60-kn winds and 49-ft swells, while the GREAT REPUBLIC (35°N, 46°W) was pounded by 52-ft swells. Many ships were indicating they were stationary and riding out the storm. There were seven reports at 1200 on the 4th of winds greater than 50 kn and all had seas and/or swells of over 30 ft. The winds ranged as high as 63 kn, with these reports scattered over the area of 40° to 48°N and 37° to 50°W. East of the storm the winds rose to 45 kn and the seas to 20 ft. By 0000 on the 5th the storm was 966 mb at 53°N, 35°W. The PROTSIONE (53°N, 28°W) had 64-kn winds on her starboard side. The reports of maximum seas and swells were in the 20- to 25-ft range. At this time another LOW was over Newfoundland and moving northeastward. The original storm was now traveling due north and weakening. By the 6th the new storm was the primary one, but the other continued north of Iceland and finally into northern Norway.

This was the storm that replaced the last one. It started near Savannah, Ga., on the 3d and traveled up the coast. The first report of high winds was on the 5th at 0600 by a ship coded LF3Q near 43.5°N, 60°W, near the center of the 972-mb storm (fig. 66).

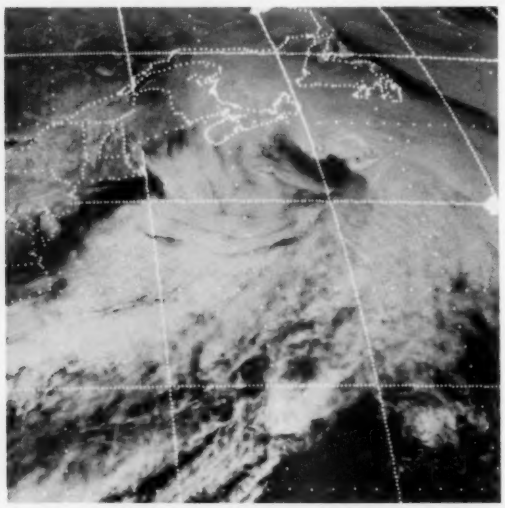

Figure 66.--A clear area at the center of the storm gives the appearance of being tropical.

Its pressure was 984 mb with 60-kn winds and 25-ft seas. At 1200 a Danish ship near 64°N, 54°W, reported 80-kn northerly winds. On the 6th the storm turned westerly and made a counterclockwise loop around Newfoundland. It was now a very large storm that reached eastward to Ireland. There were many strong winds of over 50 kn north of the center over the Labrador Sea. The JOHN CABOT had 65-kn winds with 31-ft swells near 57°N, 56°W. Another Canadian ship nearby had 56 kn with 31-ft waves. Winds of over 50 kn extended as far south as 30°N. The FROSTFJORD (42°N, 24°W) at least 1,400 mi southeast of the center reported 76-kn winds as a frontal wave moved northwest of her. On the 7th the AMBARTCHIK (50°N, 50°W) was blasted by below-freezing 76-kn winds. It was probably too cold to estimate the waves. There were still reports of storm winds and seas up to 25 ft in all except the eastern quadrant of the storm. The IMPERIAL ACADIA in the Gulf of St. Lawrence was ravaged by 80-kn winds. On the 8th the storm suddenly turned northward after completing the loop and dissipated off Greenland on the 10th as it broke into multiple centers.

Monster of the Month--Several small LOWs over the southern States merged into one center on the 10th near Cape Hatteras. Gale-force winds were blowing on the 11th as the third storm moved along the U.S. East Coast. At 1800 the storm center passed almost directly over the NNXX near 46°N, 56°W. The storm's pressure was 982 mb, and the ship's was 988 with 50-kn winds. At 1200 on the 12th the storm had two centers. A ship with only partial call letters near 45°N, 44°W, had 50-kn winds. The FAIZA (39°N, 45°W) had 41-ft swells and 20-ft wind seas.

The double-centered LOW persisted. At 1200 on the 13th one center was 974 mb at 57°N, 23°W, and the other 972 mb at 53°N, 20°W (fig. 67). The high

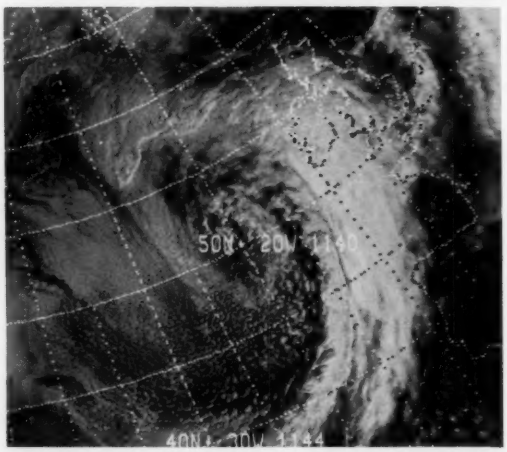

Figure 67.--This was a bad month with many storms with high winds and waves.

waves also persisted. The C.P. VOYAGEUR had 35-kn winds with 30-ft swells, the FINA NORVEGE 55 kn and 23-ft waves, and the ORDUNA had 50-kn winds with 16-ft seas and 49-ft swells south of the center near 46°N, 22°W. At 1800 the AMERICAN LEGEND suffered 39-ft seas driven by 60-kn winds. Ocean Station Vessel Romeo reported devastating 45-kn winds and 43-ft seas at 0000 on the 14th. I wonder if they were able to launch their upper air sounding balloon? At 1200 the high waves had hit Lima, but they were only 28 ft. The northern center was now tracking northwestward, while the southern center continued into the North Sea. The AMERICAN LEGEND was following the storm and continued to have 55-kn winds and 39-ft seas. On the 15th the northern center was the primary storm as far as shipping was concerned. The Ocean Weather Stations were still being hit; Charlie had 33-ft swells and Romeo 30 ft. Other ships were suffering the same fate. On the 16th both old LOWs suddenly filled, and a new center developed over Scotland, but the 25- to 30-ft seas continued. The ATLANTIC CONVEYOR was sailing westward out of the storm but still had 50-kn winds and 30-ft waves. Romeo now was tossed by 33-ft seas.

On the morning of the 16th the 233,690-ton Liberian-registered tanker AMOCO CADIZ fully loaded with 1.5 million barrels of oil was 9.5 mi off the island of Ushant (fig. 68). She was headed for Wales from the Persian Gulf. At 1045 the rudder reportedly stopped answering the helm. Attempts were made to engage the backup system but could not be accomplished owing to the pounding seas. A tug fixed a towline around 1415, but it broke about 1715. Several

Figure 68.--This is a file picture of the supertanker AMOCO CADIZ unloaded and floating high in the water. Wide World Photo.

more towing attempts failed, and the huge tanker went aground at 2204 at high tide. Helicopters took 42 of the 44 crewmen off. The captain and another officer remained aboard. On the 17th the tanker broke in two, and oil spilled from its tanks (fig. 69). The two remaining crewmembers were also rescued. Attempts to bring smaller tankers close enough to pump oil from the secure tanks were foiled by rough weather and seas. Massive cleanup operations were started, and the remaining oil was released by dropping explosives. This was the largest oil spill in history. The tanker OLYMPIC BRAVERY, in ballast, developed engine trouble in January 1976 and went aground and broke up near the same island.

On the 17th the storm crossed the Baltic Sea, and a new storm was brewing in the west.

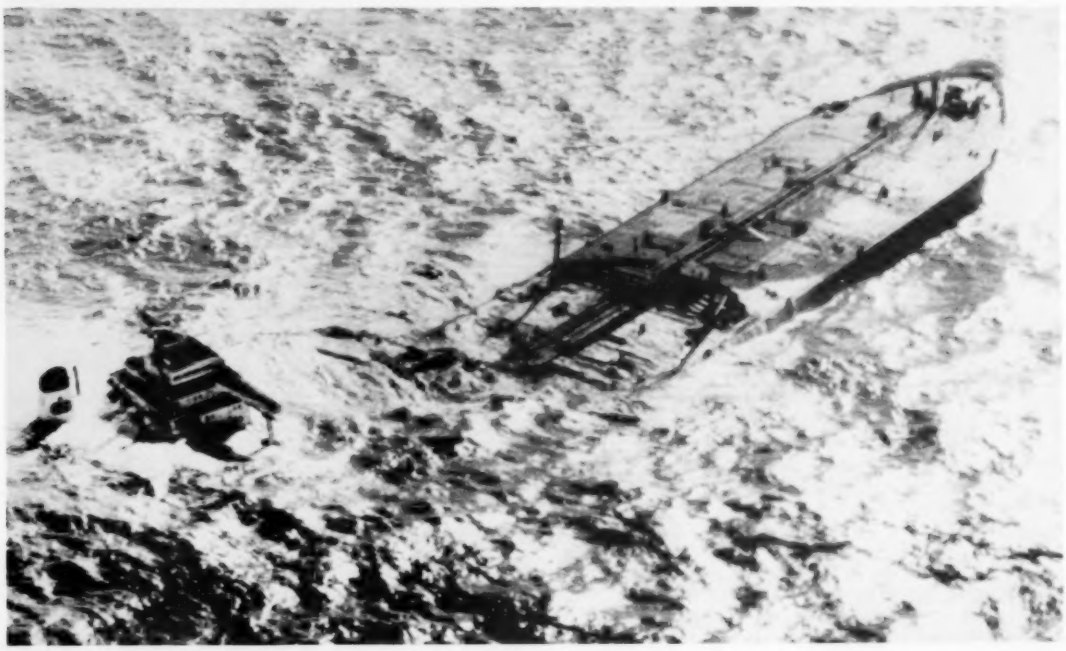

Figure 69.--This aerial view was taken of the AMOCO CADIZ after she broke in two on the rocky Brittany coast. Her entire 63 million gallons of oil eventually spilled onto the beaches. Wide World Photo.

This storm came out of the Midwest south of Chicago. It traveled northeastward up the St. Lawrence River Valley and crossed the Strait of Belle Isle on the 16th. At 0000 on the 17th the 978-mb center was at 55°N, 47°W. The JOHN CABOT was north of St. John's(50°N, 50°W) and blasted by 55-kn freezing winds. The LINDA DAN was fighting 68-kn winds and 33-ft seas off Kap Farvel. The HUDSON was near the edge of the ice on the Labrador Sea with 21-ft seas.

As the LOW moved over the southern tip of Greenland it split into two centers, one on each side of the ice cap with the eastern one surviving until the 19th. The maximum winds appeared to be near 50 kn. Several secondary LOWs formed to the south and east and moved around the periphery. At 0000 a ship near 54°N, 33°W, reported 54-kn winds and 26-ft seas. At 0600 OWS Lima measured roaring 65-kn winds and 43-ft seas, and at 1200 the seas had increased to 49 ft. Other ships plotted 20- to 25-ft seas and swells. On the 20th a secondary LOW that developed near Keflavik became the primary center of circulation. The winds and waves had reached the North Sea with 50- to 60-kn winds and seas to 33 ft. A ship near 52°N, 37°W, had 50-kn winds and 25-ft seas. Lima was now measuring 30-ft seas. Charlie reported 30-ft swells.

The LOW was moving northeastward and a trough relieved the pressure gradient over the North Sea, but the storm winds continued south of Iceland. On the 21st the LOW disappeared as another moved south of Kap Farvel.

This storm formed over Labrador south of another that had tracked across the Yukon Territory and continued into the Labrador Sea. At 1200 on the 20th the 992-mb center was near Mary's Harbour. The DART AMERICA was at 45°N, 55°W, with 53-kn winds and 26-ft seas at 1800. On the 21st the JOHN CABOT was still near the same position north of St. John's with 63-kn winds. Charlie had 45-kn gales and waves up to 28 ft. The AMSTELMEER (48°N, 31°W) and ATLANTIC COGNAC (48°N, 40°W) had winds of 50 kn or more and seas of 36 ft and 33 ft, respectively. At 0000 on the 22d, the 970-mb LOW was 400 mi east of Kap Farvel. Mostly the winds were in the 40- to 50-kn range, but many swell reports were near 30 ft in the south and southwest quadrants. SHIP reports at 0300 and 0600, which were probably OWS Charlie, showed 52- to 60-kn winds and 28- to 36-ft waves.

At 1200 on the 23d the LOW was 980 mb southeast of Iceland, and another center had formed over the North Sea. OWS Lima radioed 45-kn winds and 38-ft seas. On the 24th the new center took over.

This LOW also originated in Yukon Territory and followed in the track of the other storm. At James Bay it jumped out to head southward to the Gulf of St. Lawrence. At 1200 of the 25th the 994-mb storm was centered near 49°N, 52°W--a small storm. As the eastern circulation moved over the warmer Atlantic waters, the storm deepened rapidly. The JOHN CABOT was faithfully reporting winds of near 50 kn from near 51°N, 52°W. At 1800 on the 26th the EUROFREIGHTER (51°N, 27°W) had 60-kn winds and 38-ft seas, while Charlie measured 64-kn winds, 28-ft seas, and 44-ft swells. Her winds had decreased to 50 kn, seas 30 ft, and the swells 44 ft 6 hr later. At 1200 on the 27th there were five reports of seas or swells of 30 ft or more around the southern half of the storm. The high waves were in a northwest-southeast-oriented band that was moving eastward with the storm. The band was wide enough to keep Charlie in it until the 29th at which time they fell to a pleasant 20 ft. On the 30th the weakening storm was moving up the Norwegian coast and no longer of concern.

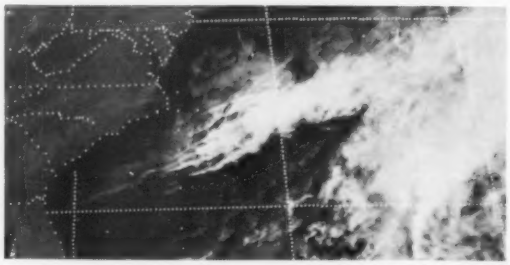

Figure 70.--The cold front is approaching Bermuda which is already cloudy from the inverted trough.

A front swept off the U.S. East Coast and joined with a LOW that was associated with an inverted trough south of Bermuda on the 30th (fig. 70). The storm moved fairly quickly northeastward and grew. On April 1 the DART ATLANTIC was near 43°N, 56°W, with northwesterly 55-kn winds. The EXPORT LEADER was headed toward Nantucket. They must have passed almost directly through the center of the storm about 0330 as indicated by their barograph (fig. 71), which plunged to 970 mb and immediately started to rise rapidly. A note on the barograph indicates 70- to 80-kn winds. This 0600 observation indicated 65-kn

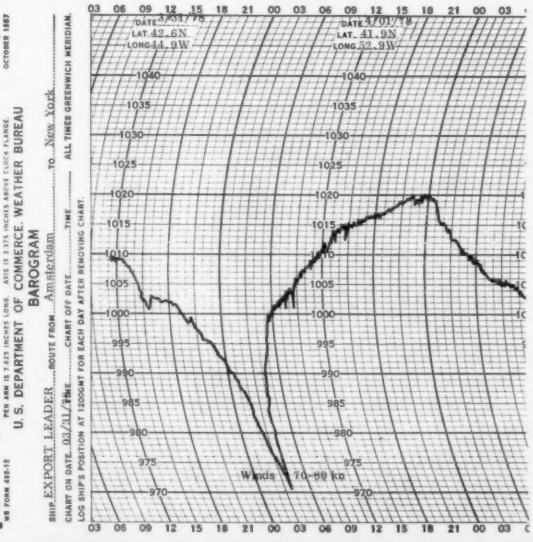
U.S. DEPARTMENT OF COMMERCE, WEATHER BUREAU
BAROGRAM
SHIP EXPORT LEADER ROUTE FROM Amsterdam TO New York
CHART ON DATE 03/31/76 CHART OFF DATE TIME ALL TIMES GREENWICH MERIDIAN.
LOG SHIP'S POSITION AT 1200GMT FOR EACH DAY AFTER REMOVING CHART.
DATE 3/31/76 LAT. 42.6N LONG 44.9W
DATE 4/01/76 LAT. 41.9N LONG 52.9W
Winds 70-80 kn
03 06 09 12 15 18 21 00 03 06 09 12 15 18 21 00 03
1040 1035 1030 1025 1020 1015 1010 1005 1000 995 990 985 980 975 970

Figure 71.--The barograph really plunged as the EXPORT LEADER passed very near the storm's center. This was accentuated by the ship and the storm moving in opposite directions.

winds from 290°. The following notation was in the remarks column: "0318Z SW-10-12 976.4 mb, 0330Z NW 10-12 972 mb." No wave reports were logged during this period. The TAIFUN (46°N, 44°W) was lashed by 80-kn winds and 38-ft seas and swells according to her 1200 report. At 0000 on the 2d, she reported 60-kn winds with 33-ft seas and 36-ft swells. Many ships were reporting winds over 40 kn and seas over 20 ft. As the storm approached 60°N on the 3d, it was deteriorating rapidly.

Casualties--The 7,062-ton Greek cargo vessel DAPO ALECOS reported heavy weather damage during a February 24 to March 8 voyage. The British vessel FINNISH WASA (15,773 tons) reported heavy weather damage at Port Canaveral on the 7th on a voyage from Hamburg. The LADY VICTORIA (10,970 tons) of Panamanian registry arrived St. Michael's on the 5th with weather damage. The 1,950-ton SECIL BRASIL of Angola registry arrived Corunna from the United States on the 15th for shelter repairs. Four persons were slightly injured. The 14,840-ton Greek cargo vessel ANNA arrived Acajutla on the 16th with alleged heavy weather damages.

The British cargo vessel KIRRIEMOOR (22,198 tons) was surveyed at Halifax owing to heavy weather from the 12th to the 21st while London to Halifax. The American MERRIMAC (15,995 tons) sustained heavy weather damage and had to unload part of her grain cargo. The 24,175-ton Liberian-registered MANITOBA 1 was under repair in New Orleans for heavy weather damage to rudder and forward superstructure owing to heavy weather on a February-March voyage. The crew of the 4,547-ton Greek freighter SARBO was rescued after abandoning ship prior to the 23d. The vessel had been aground on a reef 40 mi east of Belize since the 9th. The ship started breaking up in heavy seas while salvage operations were proceeding. The 30,280-ton Indian cargo vessel JALAVIJAYA from New Orleans was at Balboa on the 28th with hull damage from contact with a quay wall in prevailing swells.

Rough Log, North Pacific Weather

February and March 1978

ROUGH LOG, FEBRUARY 1978--The cyclone tracks generally followed the overall climatological pattern. The favorite area of cyclogenesis off the coast of Japan was farther east than normal, and the average tracks stayed farther south before turning toward Alaska after midocean. The tracks across the Bering Sea were generally storms traveling east to west, rather than the usual vice versa. Although the storms severely affected the U.S. West Coast, only two significant centers crossed the coast.

The mean pressure pattern consisted mainly of one large Low. Its 989-mb center was near 50°N, 160°W. This compares with a 999-mb climatological center near 50°N, 180°. The Pacific High at 1019 mb near 28°N, 128°W, compared favorably with climatology. The 1029-mb High over central Canada was a blocking influence on storms moving across the western mountains intact.

The 20° longitudinal displacement of the Aleutian Low produced a minus 17-mb anomaly near 49°N, 158°W. Basically, there were negative anomalies over the ocean north of 28°N. The higher pressure over Canada resulted in a positive 9-mb anomaly center north of Lake Winnipeg.

The upper air Low at 700 mb was more oval than usual with two centers about 200 ft lower than normal. The western center was not far from the climatic center near the Kamchatka Peninsula. The eastern and primary center was near 50°N, 180°. This produced a more zonal (west to east) flow over the midocean and a much sharper ridge over the Rocky Mountains. This resulted in more northerly flow off the Pacific Coast from Oregon northward.

There were no tropical cyclones this month.

Extratropical Cyclones--The first cyclone of the month came into being about 500 mi east of Tokyo on the 1st. The ARCO FAIRBANKS was headed westward into 50-kn winds near 30°N, 154°E. By 0000 on the 3d the 966-mb center was near 46°N, 179°W. The cold northerly flow west of the LOW brought heavy snow to the area of Japan facing the Sea of Japan. At Tokyo the mercury dropped to -2°C--the lowest for the winter at that time. The heavy snow caused the cancellation of more than 100 trains plus many delays. The ZEALAND VENTURE was 350 mi to the southwest with 50-kn westerlies and 13-ft seas. The FEDSTEEL was near Unimak Island with 55-kn easterlies and 13-ft seas. At 0600 they had increased to 66 kn from the southeast. At 0000 on the 4th the JAPAN ACACIA was moving eastward with the storm and had 55-kn winds and 23-ft waves in the southwest quadrant. A ship not far from the occlusion was pounding into 21-ft waves.

On the 5th the LOW split into two centers as a fast-moving storm moved in from the west. At 1200 the PHILADELPHIA near 55°N, 140°W, had 20-ft seas. Between 1200 on the 5th and 0000 on the 6th the synoptic situation changed radically. The two centers disappeared and a new one popped up south of Anchorage with a pressure of 946 mb (fig. 72). The LOW coming in from the west was racing eastward. The DIAHONSHU MARU found 58-kn winds off San Francisco. A ship far south near 35°N was sailing with 29-ft swells. The SANICO STEEL, only a few miles from Unimak Island, found 50-kn winds and 30-ft seas. The SANSINENA 2 near 43°N, 127°W, battled 50-kn southwesterlies and 25-ft waves.

On the 8th the new LOW at 960 mb was over the

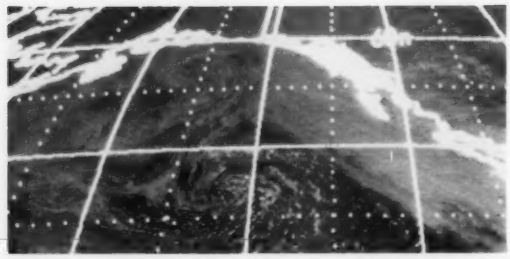

Figure 72.--The LOW of primary interest is dimly visible north of 55°N. Two other small cyclonic storms are visible south of 50°N.

Gulf of Alaska and had become the primary storm. The GREAT LAND and ASIA BOTAN east and west of the center, respectively, fought winds over 60 kn. The reported waves were 15 to 20 ft. Another cyclone had been racing eastward along approximately 40°N and turned northward as it reached the coast to replace this LOW on the 10th. Winds as high as 70 kn were found by the GLADIOLUS.

During this period this series of storms dumped near record heavy snows and high winds on the south coast of Alaska. Anchorage recorded 20.8 in and Valdez 63.4 in. Schools were closed in Anchorage for the first time since the 1964 earthquake. Storm-force winds and heavy freezing spray occurred at Kodiak Island, Alaska Peninsula, and Lower Cook Inlet. At the Barren Islands north of Kodiak there were northwesterly gusts estimated at 120 kn. Now it's known why they are called barren. On the 11th this cyclone dissipated and was replaced by another not so severe.

For about a week frontal systems had been crossing the California coast at 24 to 36 hr intervals bringing rain and high winds. The American cruise ship MONTEREY broke her mooring lines in San Francisco Bay on the 6th when winds gusted to 56 kn. On the 9th a LOW was moving northward off the Washington coast and the attendant front moved over the coast. On the 1200 analysis a frontal wave had formed near 32°N, 132°W. It deepened and consolidated as it moved eastward bringing heavy rain to southern California.

At 1200 on the 10th the 990-mb storm was centered over central California and high winds were blowing along the southern coast, bringing high seas and surf to the area (fig. 73). The ZIM HAIFA, an Israeli container vessel at Long Beach broke her stern lines in near 80-kn gusts and struck the opposite dock area. The harbor was closed from 0313 to 1202 local time. Farther south at San Diego the dredger TEXAS sank on the mudflat in the South Bay. The dredger was re-

Figure 73.--Gigantic waves are smashing over the breakwater near Cabrillo Beach and throwing water as high as 60 ft. This storm dumped more than a foot of rain on southern California and may have been one of the worst in a decade. Wide World Photo.

floated on the 16th. Flash flooding and landslides resulted from the heavy rain. On the 11th the LOW had moved inland over the Nevada-Idaho border and the storm was no longer a danger to the coastal areas.

This cyclone formed near 44°N, 170°W, on the 10th in a trough following a cold front. On the 11th a Japanese ship was sailing with 23-ft swells southwest of the center, and a SHIP had 55-kn winds and 23-ft seas southeast of the center. The PRESIDENT ROOSEVELT had 50-kn winds and 30-ft seas near 37°N, 150°W, and a SHIP nearby reported 30-ft swells. At 0000 on the 12th the LOW was 972 mb near 49°N, 139°W (fig. 74). A ship with the call sign D7OM was at 39.5°N, 144.9°W, and reported 52-kn winds from 290° with 39-ft seas and 56-ft swells from 300°. A secondary trough had passed over the ship a few hours earlier, and a closed circulation was analyzed in the trough on the 1200 chart. On the 0000 chart of the 13th the data no longer supported the existence of the original LOW.

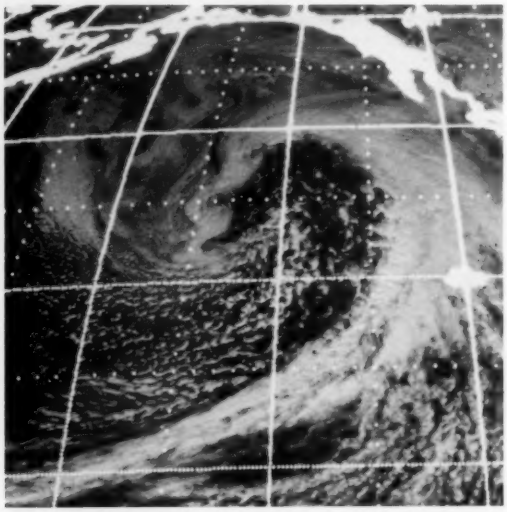

Figure 74.--This SMS satellite image was taken at 2045 on the 11th. Note the curl-type wave formations in the higher clouds west of the center.

During the first 48 hr this storm raced eastward across the Pacific at an average speed greater than 50 kn. It was first analyzed over the Yellow Sea on the 9th. As the storm sped past Tokyo on the 10th, it treated the FEDSTEEL to 60-kn northerly winds off the Japan coast. The CEDARBANK was due east near longitude 152°E with 39-ft swells. By 0000 on the 11th, the storm was 984 mb with its circulation expanding. Another LOW was centered east of the Kamchatka Peninsula, and together they were feeding very frigid air southward over the warmer ocean currents. The winds were generally gale strength with 15- to 25-ft waves.

The storm slowed considerably on the 12th as it turned northeastward. Two ships reported 30-ft waves in the southern quadrant. On the 14th the storm was moving northwestward and crossed the Alaska Peninsula. A secondary LOW had formed in the southeast quadrant and moved into the Gulf of Alaska. Winds of 50 kn and seas 15 to 25 ft were being reported. On the 15th the original LOW died over the Bering Sea as did the new storm over the Gulf of Alaska. Winds of 50 kn and waves to 30 ft were still being reported to the south of the latter LOW.

The ocean was cut up by multiple LOWs on the 18th and 19th. There were still many centers on the 20th, but this one was destined for greater things. At 0000 on the 20th the 980-mb center was near 36°N, 172°W. On the 21st ships were reporting 20- to 25-ft waves and gale-force winds south and east of the storm. The storm had a pressure of 960 mb at 0000 on the 22d (fig. 75). The SEA-LAND EXCHANGE near 48°N, 150°W, was sailing eastward with 33-ft swells. The NEWARK, PORTLAND, and PRESIDENT TRUMAN were in the Gulf of Alaska with winds over 50 kn and waves as high as 33 ft. The pressure pattern had become better organized. Another ship 750 mi southeast of this LOW and 700 mi east of another LOW had 33-ft swells striking her port quarter. The second LOW was supporting 50-kn winds and 25-ft waves.

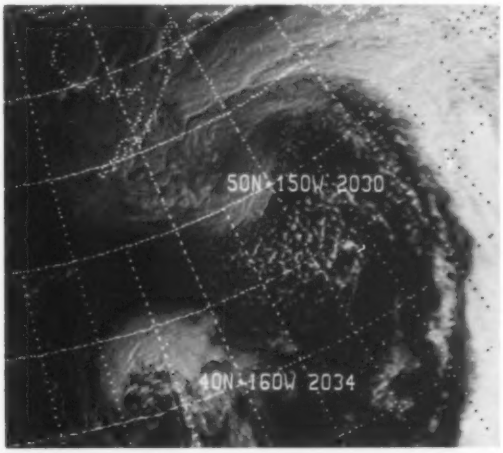

Figure 75.--The primary storm is over the Gulf of Alaska, and another is near 42°N, 168°W, and moving around the southern periphery.

At 1200 a ship near 56°N, 146°W, had 28-ft waves and the NEWARK reported 50-kn winds and 20-ft swells. At 1800 the PHILADELPHIA near 58°N, 149°W, was running with 50-kn southerlies supporting 36-ft seas and 41-ft swells. The storm was now tracking westward across the Alaska Peninsula into the Bering Sea where it dissipated on the 25th.

A Kuroshio Current storm. It developed off Tokyo on the 21st southwest of another LOW. Within 12 hr it was the primary circulation at 988 mb. At 1200 on the 22d the storm was 966 mb near 46°N, 172°E. A trough extending southwestward produced 50-kn winds with a thunderstorm. A ship with the call letters ZCJN was pounding into 50-kn westerly winds with 30-ft seas and 34-ft swells. The storm continued to

move northeastward with the PRESIDENT POLK encountering 26-ft swells about 1,000 mi south of the center. On the 25th the storm was over the Alaska Peninsula, and the buoy 46003 recorded 23-ft waves. By the 26th the storm had disappeared.

This storm formed slightly south and east of where the previous storm generated. There was evidence of cold frontogenesis early on the 24th. Two ships behind the southwest-northeast-oriented trough had 25-ft swells. On the 25th (fig. 76) the front was well established, and the SHIN HONSHU MARU about 300 mi south of the 972-mb center was traveling eastward with 50-kn winds and 30-ft swell waves. Ships east and southwest of the LOW fought 23-ft swells. At 1200 the SHUNWIND (42°N, 177°W) had 55-kn westerly winds with 20-ft seas and 33-ft swells. The storm was turning northward on the 26th as the LOW dropped to 960 mb near 48°N, 172°W. The SEALIFT PACIFIC was cruising eastward with 50-kn winds out of the west and seas of 25 ft.

As the storm moved over the cold Bering Sea, it started the deterioration process which ended on the 28th.

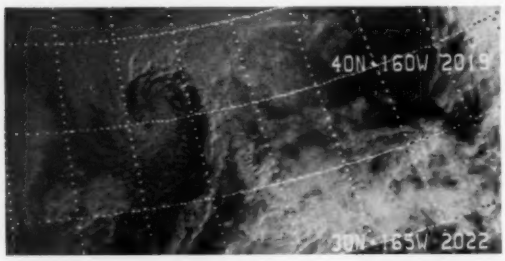

Figure 76.--At 2020 on the 24th the storm was centered near 42°N, 178°W.

As the previous storm moved eastward it left a large area of flat pressure gradient in the vicinity of the Japanese Islands, as the cold high pressure over Asia remained stationary. As usual in nature and meteorology, this situation does not exist for long, and a cyclonic circulation was found on the analysis of the 25th.

By 0000 on the 27th the LOW was 980 mb near 39°N, 179°W. At that time two ships radioed 50-kn winds, with one measuring 33-ft swells. Only 24 hr later the central pressure had plunged to 959 mb. The storm had caught up to the SEALIFT PACIFIC, and she had 70-kn winds with 41-ft seas near 40°N, 166°W. There were six other reports of 60 kn or more near the storm with several containing waves over 25 ft. There were few reports at 1200, but the SEA-LAND COMMERCE north of the center found 50 kn and 30 ft. At 0000 on March 1 a Japanese ship near 49°N, 178°W, was about 150 mi northwest of the 966-mb center with 43-ft swell waves. The SEA-LAND COMMERCE was headed toward Seattle with 30-ft waves. By the 2d another center had become primary.

This storm barely made the month. It developed over the Sea of Japan late on the 27th. By 0000 on March 1 it was 970 mb slightly east of Hokkaido (fig. 77). Strong winds raged along the Pacific coast of Honshu

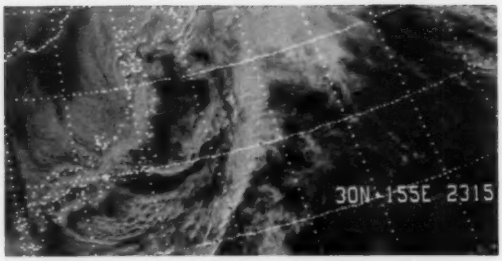

Figure 77.--This image was taken late on the 28th as the storm brought high winds to Honshu and caused much damage.

from the 28th to the 1st, causing heavy weather damage to houses and disrupting air and rail services. There were 2 deaths and 50 injuries attributed to the high winds. Winds up to 78 kn were recorded in Tokyo. The 12,947-ton Liberian freighter SEVENSEAS with a cargo of logs ran aground in high winds off Akita in northern Honshu. The LAURENTIAN FOREST was headed toward Tokyo and found 60-kn winds with 20-ft waves at the cold front. At 1200 a ship that appeared to be the TRIUMPH along the occluded front near 41°N, 158°E, had 45-kn winds, 13-ft seas, and giant 46-ft swells. There were many reports of winds greater than 50 kn and waves up to 30 ft. Late on the 2d a SHIP near 37°N, 155°E, claimed 45-ft swell waves. At that time a new LOW formed at the point of occlusion and raced eastward. The tighter gradient was still with the original LOW and the ZCJN at 36.4°N, 154.1°E, had 60-kn westerly winds with 33-ft seas and 46-ft swells. Swells of 30 ft were being found as far as 800 mi south of the LOW.

The storm was now a double-centered LOW, both moving eastward. The circulation was nearly circular and covered a large part of the ocean. The winds were generally in the gale category with waves up to 25 ft. On the 4th the original LOW was replaced by another.

Casualties--The 41,750-ton EASTERN MOBILITY, Los Angeles for Singapore, arrived on the 3d with heavy weather damage. The 14,000-ton American cargo vessel MAINE arrived Seattle on the 6th with 17 yachts lost overboard during heavy weather. The 3,740-ton barge POWELL CARRIER sustained hull damage off Point Sur during heavy weather on the 11th. Approximately 75 percent of the cargo of lumber was washed overboard. The Greek SEASPEED AMERICA encountered heavy weather after leaving Yokohama on the 11th and 55 containers were damaged. The Indian cargo vessel CHENNAI OOKKAM (24,365 tons) encountered heavy weather between Japan and Vancouver. Another Indian vessel, the MARATHA PROVIDENCE (39,480 tons) reported need of assistance due to weather damage arrived Yokohama on the 14th. The 4,967-ton ZEPHUNTER left Tacoma on the 11th and encountered force 8 winds west of Cape Flattery on the 12th, which broke lashings and allowed cargo to move. The ship returned to Tacoma.

The 11,434-ton WORLD PRIDE was due Osaka on the 20th with heavy weather damage. The 12,943-ton tanker ATHENIAN HORIZON reported heavy weather

damage at Shanghai on the 23d. The 7,027-ton MARGUERITE VENTURE encountered heavy weather between Papeet and Apia on the 24th. Containers broke loose and punctured tanks.

ROUGH LOG, MARCH 1978--The storm centers in the western ocean closely followed the climatological paths, but they were not so consistent in the eastern half. There was a primary path toward the east-northeast from along the south coast of Japan into the Bering Sea. A secondary part of that track became part of a primary track at midocean and extended into the Gulf of Alaska. This part was farther east than climatology indicates. A secondary climatological track from the southern Gulf northward to Alaska became a primary one with more travel. The storm path into the U.S. West Coast was farther south than normal.

The overall pressure pattern closely paralleled climatology. Normally, the Aleutian Low has two centers, but his month they were reversed. The deepest Low at 999 mb was in the Western Hemisphere near 51°N, 171°W. The deepest Low is normally in the Eastern Hemisphere. The secondary Low was 1000 mb southeast of Kamchatka. These were 8 mb and 5 mb lower than the mean, respectively. The Pacific High at 1021 mb near 30°N, 157°W, was 1 mb lower and about 800 mi west of its mean.

The primary anomaly was -11 mb at 50°N, 165°W. South of Kamchatka near 45°N, 160°E, there was a -8-mb and a -6-mb center off San Francisco near 37°N, 137°W. The most significant positive anomaly was 6 mb over Siberia north of Kamchatka.

In the upper air at 700 mb there were also double low centers with the anomalous one near Adak, Alaska. The normal center over the Sea of Okhotsk was southeast of the tip of Kamchatka. This resulted in a broader trough off the Asian coast. The anomalous Low resulted in a sharper trough off the North American west coast and ridge over the mountains.

Extratropical Cyclones--On the 2d, there were four LOWs and two HIGHs over the Pacific between latitudes 15°N and 60°N. On the 0000 chart of the 3d a new LOW had formed between Hawaii and the U. S. West Coast. The TENNESSEE MARU was about 150 mi southwest of the 984-mb center (37°N, 151°W) with 50-kn winds and 16-ft waves. Three hours previously she had reported 54 kn and 20-ft waves while southeast of the center. At 0600 two ships reported 55-kn winds in the vicinity of 33°N, 148°W, the waves were 20 to 30 ft. At 1800 a SHIP at 30°N, 144°W, fought 64-kn westerlies and 31-ft swells (fig. 78). On the 4th the storm's center was nearing the northern California coast with high waves and heavy rain along the coast (fig. 79). The EASTERN CITY was over 300 mi southwest of the center with 54-kn winds and 30-ft waves. On the 5th there were still ship reports

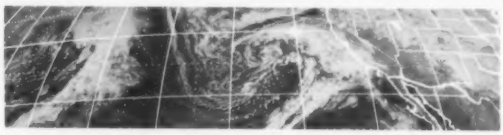

Figure 78.--Late on the 3d, the center of the storm is still off the California coast.

Figure 79.--High surf splashes workers as they attempt to install a temporary retaining wall to protect beachfront homes. Wide World Photo.

of 20-ft waves, but by that evening the storm dissipated over northern California.

This was a slow-moving storm. It was also one that went for a long period with a double center. It formed on an occlusion over the Sea of Japan on the 3d and moved across the Tsugaru Strait early on the 4th. On the 5th the 990-mb storm was at 44°N, 153°E. The PRESIDENT MONROE was near 34°N, 148°E, slightly north of an incipient frontal wave with 55-kn northerly winds. On the 6th the JAPAN RAINBOW was north of the storm's center with 61-kn winds, as a second low center had formed at the point of occlusion. The GEORGIANNA twice reported winds over 50 kn on the 7th. The original LOW was moving eastward very slowly, while the eastern center picked up speed and was increasing the distance between the two centers. The FERNIE was 600 mi south of the center with 55-kn winds and 18-ft swells on the 8th. By the 9th the western LOW had deteriorated to only a trough, while the eastern center had raced into the Bering Sea to disappear on the 10th.

This LOW developed in the far south circulation of the LOW above as it filled over the Bering Sea on the 10th. A ship found 20-ft swells west of the center in the area where the fetch extended from the Bering Sea. The winds were only 20 kn. The storm deepened rapidly as it moved northward, and it was 959 mb near 48°N, 164°W, at 1200 on the 11th (fig. 80). On the 12th the storm crossed the Aleutian Islands. The MAKHTUMKULI (53°N, 170°W) was battling 64-kn westerly winds. The KENRYU MARU (52°N, 167°W) contended with 50-kn winds, but reported 28-ft seas. The RHEIN MARU was 700 mi south near 43°N, 165°W, with 40-kn winds and 33-ft seas and swells. Ocean buoy 46003 reported 25-ft seas. On the 13th a ship whose call letters were obscured by the analysis reported 40-kn winds with 25-ft swells near 45°N, 176°W. The LOW was now dissipating as the center moved westward over the Bering Sea. The RHEIN MARU (43°N, 174°W) reported 33-ft swells on the 14th, as a secondary LOW kept the northwesterly circulation over the area.

This storm also began on the 10th, but over Japan. It formed south of and in the circulation of a LOW that came out of the Yellow Sea into the Sea of Japan. Three Soviet ships were near 37°N, 141°E, with 50- to 60-kn winds. The seas were up to 16 ft. On the 11th there was only the southern LOW as a center. The SEA-LAND TRADE was south of the LOW with 53-kn northwesterly winds, while the JAPAN RAINBOW was northeast of the center with 68-kn winds. On the 12th a small LOW formed on the occlusion, and the GLADIOLUS found 58-kn westerly winds about 200 mi south of the center. The new center raced off to the east under the upper air zonal flow, and another center materialized south of the old center.

Late on the 16th a wave was analyzed on a weak stationary polar front. The storm was 1000 mb at 0000 on the 17th, and the EASTERN CITY had 58-kn winds near a trough line behind the front. Twenty-four hours later the pressure had plunged to 976 mb near 45°N, 178°W. The TAIZAN MARU was south of the center with 60-kn winds, and the EDEN MARU was to the north with 56 kn and 26-ft waves. By 1200 on the

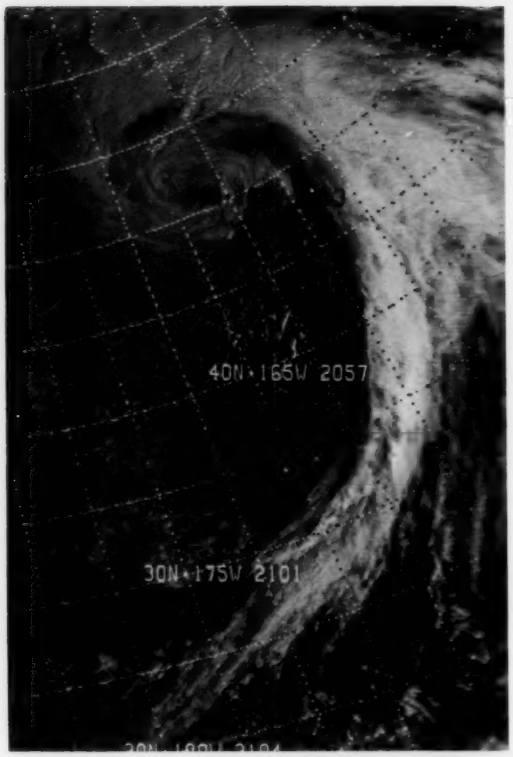

Figure 80.--The storm moved 6° latitude between the 1200 chart and 2053, the time the satellite passed over the area.

19th the storm had moved to 55°N, 165°W. Three Japanese ships south of the center had 50- to 60-kn winds with 26- to 50-ft waves. The ASIA MARU reported 50-ft seas and 33-ft swells. Early on the 20th several ships had seas and/or swells to over 30 ft, but by late in the day the storm was rapidly deteriorating as it moved over land.

A col area existed over the Sea of Japan on the 18th, and late in the day a LOW developed south of the Islands. It quickly deepened over the Kuroshio Current and at 0000 on the 20th was 970 mb at 40°N, 153°E. The FEDSTEEL near 34°N, 148°E, reported 78-kn northwesterly winds and 23-ft seas and swells. Other ships were calling the winds more than 60 kn and the waves to 30 ft. At 0600 the KENRYU MARU (37°N, 150°E) had 50-kn winds, 33-ft seas, and 43-ft swells. There were also high waves (31 ft) east of the center and north of the occlusion. On the 21st the NEPTUNE RUBY was sailing eastward as the storm moved northward and twice reported winds over 50 kn and seas and swells of 23 ft. The storm was still about 970 mb, but it was losing its circulation to another LOW from south of Japan. On the 23d it was gone.

This was the storm that absorbed the one above. It

formed over the East China Sea on the 20th. It raced eastward under the upper air flow bringing heavy rain to Japan and gales to shipping in the area. The storm was 972 mb near 42°N, 154°E, at 0000 on the 23d. The PACIFIC ARROW was south of the center with 50 kn and 20-ft waves. The VICTORIA CITY (43°N, 165°E) had 55-kn winds and 41-ft seas on her starboard bow. At 1200 an American ship was stationary near 51°N, 176°E, and reporting 66-ft swells. The height looked suspicious, but the pressure, wind, swell direction, and ship movement indicated it must be a good report. Many times interference during the retransmissions of these reports results in errors when they are finally plotted.

On the 24th and 25th the winds were in the gale or lower category with an isolated swell report near 20 ft. On the 26th the PRESIDENT JEFFERSON (49°N, 167°E) had 45-kn gales and 33-ft swells south of the center. The storm was now turning westward to disappear on the 27th.

A trough that moved over Japan on the 25th became a LOW on the 26th. The LOW was 986 mb on the 28th. A ship had 50-kn winds, 26-ft seas, and 30-ft swells at 1200 while 300 mi southwest of the storm's center. The PRESIDENT TAFT found 21-ft waves 500 mi to the southeast of the center. On the 29th the maximum winds plotted were 45 kn, but two ships south of the storm reported 30-ft swells. On the 30th a ship had 45-kn gales, 25-ft seas, and 33-ft swells far south of the center (51°N, 170°W) in the westerly flow. As the storm moved over the Gulf of Alaska on the 31st, it dissipated.

Another East China Sea storm. It formed on the 27th south of Korea. On the 28th there were two other small LOWs north of the Sea of Japan. By 1200 on the 29th this LOW had absorbed these and their cyclonic circulation. The storm was now 980 mb off Hokkaido (fig. 81). On the 30th a SHIP (38°N, 158°E) was sailing eastward with 45-kn northwesterlies and 31-ft swells from the west-northwest. On the 31st most of the winds around the storm were less than 30 kn, but there were isolated high-swell reports. A Japanese ship northwest of the center was sailing with 33-ft swells from the northeast on her stern, and the IRISH ELM south of the center had quartering 25-ft swells. On April 1 secondary LOWs on the periphery of the storm partially robbed it of its energy and violence and it disappeared by the 2d as one of these became the primary storm.

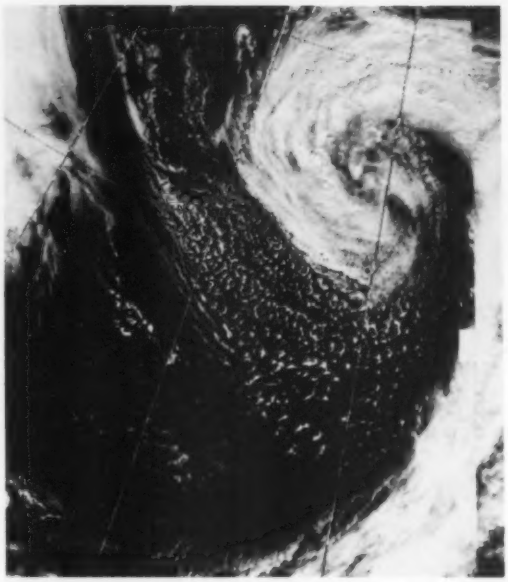

Figure 81.--This DMSP imagery was obtained from the Air Force. The sensor on NOAA-5 ceased to operate on March 16.

Casualties--The 35,677-ton British-registered EASTERN CITY requested survey of heavy weather damage alleged to have occurred on March 3 and 4. The Liberian-registered 11,169-ton GOLDEN EXPLORER was at Wakayama on the 13th and reported heavy weather damage on a voyage from the Columbia River to Kobe. At the same time the 9,954-ton SUN CHONG reported heavy weather damage during a trip from Los Angeles to Yokohama.

The 21,495-ton American PRESIDENT ROOSEVELT and the 2,990-ton Thai CHAMNARN SAMUT collided in heavy fog in Hong Kong Harbor on the night of March 27. The Thai freighter lost one crewman and another was injured. Both vessels were damaged. Within 24 hr two more ships collided in fog near Hong Kong, southeast of Wagland Island. The ships involved were the 2,625-ton Indonesian PAN ASIA SATU and the 4,000-ton Chinese RED FLAT 153. Neither ship was seriously damaged.

Marine Weather Diary

NORTH ATLANTIC, JUNE

WEATHER over the North Atlantic is usually very pleasant in June. The number of active extratropical LOWs continues to decline, and storms are usually confined to the higher latitudes--centers north of 45°N over the western ocean and 55°N over the eastern ocean. The building Azores High averages near 1024 mb for the month and is centered over midocean near 33°N, 38°W. The Icelandic Low, oriented east-west, is quite diffuse with the lowest average pressure about 1010 mb, just off the coast of Labrador, near 58°N.

WINDS are controlled largely by the Azores High, with the transient LOWs causing the daily variations. Between 25° and 55°N, southwesterly winds predominate, except over the eastern ocean from the Bay of Biscay southeastward, where northerly winds prevail. South of 25° to about 5°N, the "northeast trades" are generally steady. North of 55°N, winds are mostly variable. On the Mediterranean, east to southeast winds are common over the western half, while northwest winds blow steadily over the eastern portion. Northerly winds are predominant off the Iberian Peninsula and northwest coast of Africa. Northwesterly winds prevail over the eastern Gulf of Mexico, while southeasterly winds are predominant over the southern North Atlantic between the Equator and 5°N. Windspeeds over most of the North Atlantic during June are force 3 to 4. Lighter force 2 to 3 winds are most common over the Mediterranean Sea, Davis Strait, Gulf of Mexico, Bay of Biscay and waters southwestward, and near the Equator. A band of force 4 to 6 extends northeastward from the vicinity of Bermuda toward Ireland.

GALES over the North Atlantic are infrequent during June. Only in the waters near southern Greenland and over northern portions of the Norwegian Sea does the probability of encountering gales exceed 10 percent.

EXTRATROPICAL CYCLONES are fewer in June than in May and not as intense. Cyclogenesis throughout the summer occurs principally in the area from the Carolinas, west of 65°W, to Hamilton Inlet, Labrador, west of 50°W; north of Scotland; northwest of Iceland; over the waters southwest of the British Isles; and over the Gulfs of Finland, Riga, and Bothnia. The major storm tracks during June extend from the Newfoundland area northeastward to the waters south of Iceland, and then east-northeastward across the Scandinavian Peninsula. Another primary track extends from Iowa across central Lake Michigan to southern Lake Huron and down the St. Lawrence River, where it joins a track that develops off Cape Cod.

TROPICAL CYCLONES. Tropical storms average about one every 2 yr. The preferred area of tropical cyclone formation is over the western Caribbean and the Gulf of Mexico. The 47-yr period, 1931-77, had 25 tropical storms, of which 11 reached hurricane strength.

SEA HEIGHTS of 12 ft or more occur between 5 and 10 percent of the time over a broad area that includes the Labrador Sea, around the southern Greenland coast into Denmark Strait, then south of Iceland to the Faeroe Islands and southward to off Ireland's west coast, then southwestward to about 500 mi off Cape Race, and northwestward to include again the Labrador Sea. Other small areas are located between Norway and the Shetland Islands, off the central Norwegian coast, and in the Gulf of Lions. Frequencies of 10 percent or more occur only over an elliptical area immediately south of Kap Farvel. A flat oval area of swell greater than 12 ft over 10 percent of the time is centered about 55°N, from south of Kap Farvel to Ireland. The oval changes from about 5° to 10° of latitude thick from west to east. An area of over 20 percent occurs about 200 mi off the coast of Colombia.

VISIBILITY. The frequency of fog approaches its maximum over the northern ocean. The Grand Banks is the foggiest region--visibility below 2 mi is reported on more than 30 percent of all observations. The percentage of this low visibility decreases to between 20 and 30 percent of the observations over the Davis Strait and the northern Labrador Sea, and over the waters east of Kap Brewster, Greenland. The latter area is usually ice-covered at this time of year. The fog is generally observed in warm, moist air brought by southerly winds into this area of cold ocean temperatures.

NORTH PACIFIC, JUNE

WEATHER. The summer regime is well established over the North Pacific in June. Vigorous extratropical storms are increasingly less frequent. The Subtropical High is centered near 36°N, 149°W, and has an average central pressure of about 1022 mb. The Aleutian Low, located north of the western Aleutian Islands, fills rapidly during June; by the end of the month, it has disappeared, leaving only a trough.

WINDS north of the trade wind belt are variable over the broad scale, ranging from northwesterly to northerly off the United States and Canadian coasts, to southerly east of Japan, to westerly over the Aleutians. Over the Gulf of Alaska, they are southerly to westerly. Northeast of Hawaii, the winds blow from the northeast. The speeds average force 3 to 4 north of 25°N. South of 25°N (30° east of 145°W) to the Equator, steady "northeast trades" dominate, with force 4 the most common speed. The southwest monsoon is established over the South China Sea. Southeasterlies prevail over the Philippine Sea, switching to southerly south of Japan and Korea.

GALES are rare in June. Only over a small area near 46°N, 145°W, does the chance of encountering gales exceed 5 percent.

EXTRATROPICAL CYCLONES. The most favorable area for cyclogenesis continues to be east of Honshu.

The primary storm tracks lead from here east-northeastward to the Gulf of Alaska. Another track approaches the Gulf of Alaska on a northeasterly course from midocean.

TROPICAL CYCLONES. The probability of tropical storm development continues to rise sharply in June, approaching the late summer and early fall maximum. On the average, three of these storms develop per year--one or two during this month in Asiatic waters, and one or two over the ocean area between 10° and 20°N, and the Mexican west coast and 120°W. About two out of three western North Pacific tropical storms go on to become typhoons. One out of three eastern North Pacific storms reach hurricane intensity.

SEA HEIGHTS of 12 ft or more have a frequency greater than 10 percent only in two small areas. One is centered south of the Alaska Peninsula near 48°N, and the other south of the western Aleutians near 46°N. Generally, sea conditions are improving as summer approaches. Areas of high swell are located in the northern Gulf of Alaska and Bering Sea, south of the ice edge.

VISIBILITY. The frequency of low visibility increases over most of the North Pacific. The waters east of the northern Kuril Islands are particularly foggy, with the visibility dropping below 2 mi in over 40 percent of the observations. From the outer boundaries of this area northward to Kamchatka, southward to the central Kurils, westward to the eastern Sea of Okhotsk, and eastward to 162°E, this percentage drops to 30 to 40 percent of all observations. The area of low visibility, which encompasses 20 to 30 percent of all observations, extends from the southern Sea of Okhotsk through the central Kurils, and then eastward through the North Pacific along the 40th parallel to 165°W. The line bordering the boundary of the area then bends westward to midocean near 47°N, 175°E, before curving northeastward through the central Aleutians to St. Lawrence Island in the Bering Sea.

NORTH ATLANTIC, JULY

WEATHER conditions are relatively settled during July as the Azores High, centered near 35°N, 44°W, builds to a seasonal maximum of about 1025 mb, and primary storm tracks are displaced north of 45°N. The Icelandic Low remains an ill-defined east-west trough with the lowest pressure, about 1009 mb, centered near Hudson Strait in eastern Canada.

WINDS over the middle and northern latitudes have southerly and westerly components. Northerly winds are common near the entrance to the Mediterranean, while over the Sea itself, northwesterly winds are steady. Winds from the northerly quarter are found over the North Sea, off the central Norwegian coast, and over the Davis Strait and the waters southwest of Iceland. The "northeast trades" blow between 10° and 25°N, while in the Gulf of Mexico, easterly winds are most frequent. Near the Equator, southeasterlies dominate the area between South America and Africa. Windspeeds average about force 3 to 4 over most of these areas except over the Mediterranean Sea, the Davis Strait, and the Gulf of Mexico, where force 2 to 3 winds are prevalent. The strongest winds, of which nearly two-fifths of all observations are force 5, are encountered over the waters of the southwestern Caribbean Sea.

GALES. The frequency of gales is at a minimum for the year. Only over the Norwegian Sea is the percentage frequency of gales 10 percent or higher.

EXTRATROPICAL CYCLONES. From June to July, a marked northward shift of cyclonic activity occurs over the North Atlantic. Areas of cyclogenesis are along the North American coast from the Carolinas to north of Newfoundland, in the Denmark Strait, southwest and north of the British Isles, in the Adriatic Sea, and over the Gulfs of Bothnia, Finland, and Riga. The primary cyclone tracks lead from the Hudson Bay region northeastward through the Davis Strait, from the Grand Banks and the Gulf of St. Lawrence toward Iceland, and from north of Scotland eastward across southern Scandinavia. Two secondary tracks cross the Great Lakes. One extends from the Great Plains across eastern Lake Superior toward Labrador, while the other cuts an east-northeasterly swath across Lakes Erie and Ontario, New York, and New England, before merging with the Carolina storm track over the Gulf of St. Lawrence.

TROPICAL CYCLONE activity is still limited. On an average, three storms will occur during a 4-yr period, and half will develop into hurricanes. July tropical cyclones usually originate over the Gulf of Mexico or just east of the Lesser Antilles. Those forming over the Gulf generally move northward across the Gulf Coast, while those born east of the Lesser Antilles may move westward across the Caribbean Sea, or northwestward toward the southeast coast of the United States, where they often recurve to the northeast. Sometimes these storms are bred north and east of the Bahama Islands during July.

SEA HEIGHTS of 12 ft or more are encountered with a frequency of 10 percent or more only in a small area immediately south of southern Greenland.

VISIBILITY. Like June, July is one of the foggiest months of the year over the western North Atlantic. Observations with visibility less than 2 mi average 10 percent or more northward of a line drawn from the waters between Cape Cod and Cape Sable northeastward to near 60°N, 30°W. From there, the 10-percent frequency line runs eastward, south of Iceland, to near the Faeroe Islands, and then southward, cutting across Scotland near the Firth of Forth. The line then extends northward along the Prime Meridian to about 63°N, where it heads northeastward to the coast of Norway. The 20-percent frequency line is a little less erratic. It extends from near Cod Island, Labrador, eastward to near 56°N, 47°W; it then extends southwestward across Newfoundland to the Grand Banks. From there, visibilities less than 2 mi occur 20 percent or more of the time west of a line drawn to the coastal waters of Greenland, near Kap Mosting, and then north of the same line extended to 74°N, 20°E. Enclosed within the area defined by Godthaab (Green-

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land), Resolution Island, and Ivigtut (Greenland), observations with visibility less than 2 mi exceed 30 percent.

NORTH PACIFIC, JULY

WEATHER. The steady and rather settled summer weather conditions that commenced in June over the North Pacific become widespread and firmly established during July. The Aleutian Low has disappeared from the pressure chart of normals, and the Subtropical High, with a pressure of 1026 mb, has moved northward to near 38°N, 150°W.

WINDS. Because of the strong development and northward position of the Subtropical High, the "northeast trades" extend over a large portion of the ocean. They prevail over all but Asiatic waters south of 30°N. Over the eastern ocean, they extend northward to about 35°N. The southwest monsoon is well established in Asiatic waters, blowing most steadily over the South China Sea. The westerlies of the middle latitudes, because of the absence of the Aleutian Low, are less steady than during the colder months. Large southerly components are found over the western two-thirds of the ocean at these latitudes, while northerly components are the rule closer to the conterminous United States and are also observed out from the Gulf of Tehuantepec. Easterly winds prevail over the waters of the Gulf of Alaska. Windspeeds over the Pacific average slightly less than force 4.

GALES associated with extratropical cyclones are rare during July over almost all of the North Pacific, but a frequency greater than 5 percent does exist over a 2° square north of the central Aleutians.

EXTRATROPICAL CYCLONES. Cyclogenesis during the summer occurs in Asiatic waters from Taiwan northward to Sakhalin, and northeastward to the Near Islands. The greatest frequency is east of Honshu and Hokkaido. Two other areas are found near 47°N, from 155° to 175°W, and over the Gulf of Alaska. The primary storm tracks lead from Honshu northeastward to the Bering Sea, and from a point near 52°N, 157°W, to the Gulf of Alaska.

TROPICAL CYCLONES. Usually three or four tropical storms occur over the western North Pacific during July. Only one of these will not become a typhoon. These storms originate mostly over the ocean areas east of the Philippines. During their early stages, they generally move west-northwestward; after development, some may continue across the northern Philippine Islands into the South China Sea, while others curve northwestward toward Taiwan, the coast of mainland China, Korea, or Japan. Those reaching higher latitudes generally recurve toward the northeast under the influence of the upper westerlies.

Another area of tropical cyclone activity is over the waters off the west coast of Mexico. Around four tropical storms can be expected in July, with one reaching hurricane force. These storms are usually shorter lived, but can be dangerous to both marine and coastal interests. They normally move west-northwestward out to sea, but sometimes they pass inland over Baja California.

SEA HEIGHTS of 12 ft or more may be expected about 10 percent of the time in two small areas south of the Aleutians, near 48°N, 165°E, and near 49°N, 155°W. Areas of high swells are located in the Gulf of Alaska and Sea of Okhotsk.

VISIBILITY. Compared to other months of the year, the occurrence of low visibility over northern waters is most frequent during July. The visibility drops below 2 mi in over 40 percent of all observations over a circular area bordering the northern Kurils on the west and centered near 48°N, 158°E. The 30-percent frequency line is less circular, running from southwestern Kamchatka across the central Kurils to a point near 43°N, 160°E, and then northeastward to the Rat Islands, before swinging westward to Mys Shipunskiy. The 20-percent frequency line also crosses the central Kurils, but extends farther up the west coast of Kamchatka. This line then continues southeastward from the Kurils reaching south of 40°N, between 160°E and the dateline, before moving east-northeastward to a point near 48°N, 145°W, and then north-northwestward to Afognak Island. The entire Bering Sea is enclosed within this 20-percent frequency line, with the exception of the waters northeast of St. Lawrence Island, and the waters north of a line drawn from Mys Ozernoy to Mys Navarin. The 10-percent frequency line is very similar to the 20-percent one. It stretches from the northern Sea of Okhotsk southward to the southern Kurils; it then continues southeastward to a point near 34°N, 170°E, before shooting east-northeastward to about 40°N, 140°W, and then north-northwestward to the Gulf of Alaska.